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# ANNUAL REPORT

OF THE

# SECRETARY OF WAR

FOR

# THE YEAR 1879.

IN FOUR VOLUMES.

## VOLUME II.

### PART III.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1879.

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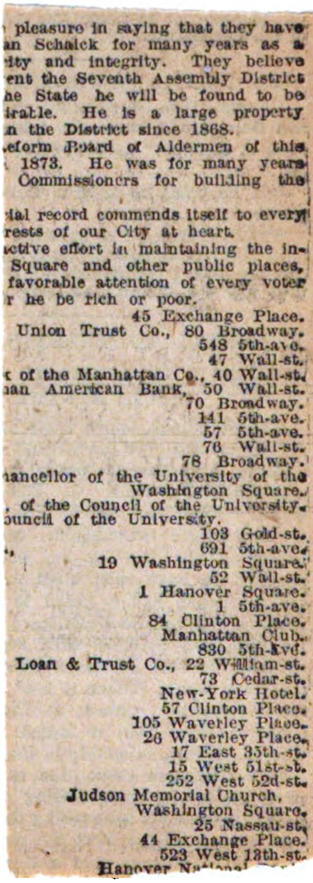


pleasuro in saying that they have
an Schaick for many years as a
ity and integrity. They believe
ent the Seventh Assembly District
he State he will be found to be
irable. He is a large property
n the District since 1868.
eform Board of Aldermen of this
1873. He was for many years
Commissioners for building the

ial record commends itself to every
rests of our City at heart.
ctive effort in maintaining the in-
Square and other public places,
favorable attention of every voter
r he be rich or poor.

45 Exchange Place.
Union Trust Co., 80 Broadway.
548 5th-ave.
47 Wall-st.
of the Manhattan Co., 40 Wall-st.
an American Bank, 50 Wall-st.
70 Broadway.
141 5th-ave.
57 5th-ave.
76 Wall-st.
78 Broadway.
ancellor of the University of the
Washington Square.
, of the Council of the University.
ouncil of the University.
103 Gold-st.
691 5th-ave.
19 Washington Square.
52 Wall-st.
1 Hanover Square.
1 5th-ave.
84 Clinton Place.
Manhattan Club.
830 5th-Ave.
Loan & Trust Co., 22 William-st.
73 Cedar-st.
New-York Hotel.
57 Clinton Place.
105 Waverley Place.
26 Waverley Place.
17 East 35th-st.
15 West 51st-st.
252 West 52d-st.
Judson Memorial Church,
Washington Square.
25 Nassau-st.
44 Exchange Place.
523 West 13th-st.
Hanover

# APPENDIXES

TO THE

# REPORT OF THE CHIEF OF ENGINEERS.

(CONTINUED.)

# SURVEYS AND EXPLORATIONS.

## APPENDIX M M.

## SURVEY OF THE NORTHERN AND NORTHWESTERN LAKES AND THE MISSISSIPPI RIVER.

### ANNUAL REPORT OF MAJOR C. B. COMSTOCK, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1879.

UNITED STATES LAKE SURVEY OFFICE,
*Detroit, Mich., July* 1, 1879.

GENERAL: I have the honor to submit the following report on the Survey of the Northern and Northwestern Lakes and Mississippi River for the year ending June 30, 1879:

### LAKE ERIE.

In July, 1878, Assistant Engineer E. S. Wheeler began the measurement of a primary base line with the Repsold base apparatus at Cedar Point, near Sandusky, Ohio, and completed it in October, having measured it in both directions.

This base having two angles in it, thus breaking it into three parts, a fourth point was selected, so as to give well-shaped triangles, and the angles of the triangles formed by these four points were read by First Lieut. P. M. Price, Corps of Engineers.

Some of the angles in the Lake Ontario triangulation having shown discrepancies larger than was desired, they were remeasured by Assistant Engineer R. S. Woodward.

As soon as the appropriation for 1879 became available, the erection of stations to complete the chain of triangles connecting Lake Michigan with Lake Erie was begun and completed.

In September, 1878, Assistant Engineer G. Y. Wisner began reading their angles at Sturgis, Mich., and continued the work till November 8, when he was recalled to be sent upon the Mississippi River survey.

On May 1, 1879, the reading of the angles of this triangulation was recommenced by parties under Assistant Engineers G. Y. Wisner, R. S. Woodward, and J. H. Darling, and at the date of this report the work is nearly completed. The erection of the stations for the triangulation running south from Chicago to connect with the Coast Survey triangulation in Illinois has been begun.

### MISSISSIPPI RIVER SURVEY.

As soon as the disappearance of the yellow fever at Memphis in the fall of 1878 permitted, the survey of the Mississippi River was resumed at Scanlan's Landing on November 24. First Lieut. D. W. Lockwood was charged with the borings to determine the character of the river bed; with the measurement of a secondary base line; with the moving and supplying of the parties, and the general arrangement of the survey.

The secondary triangulation was carried by First Lieut. P. M. Price and Assistant Engineer G. Y. Wisner, from the line Fairview—State line to the line Helena Island—Adams, a distance of 52 miles, measured along the river. Lieutenant Price devised some portable stations which proved very useful. A base line was measured by Assistant Engineer Wisner with the secondary base apparatus at Harbert's Point. Lieutenant Price determined the azimuth of the base line by three nights' observations on circumpolar stars.

The topography and soundings were carried on by the parties of Assistant Engineers J. A. Ockerson, J. H. Darling, and John Eisenmann. The topography was completed from Scanlan's down to Mrs. Baldwin's, and the shore line and soundings to Walnut Bend, a distance of 33 miles below Scanlan's.

In addition, for the use of the Board of Engineers on the low-water navigation of the Mississippi River, the shore-line, slopes, and soundings were carried by Assistant Engineer Ockerson from O. K. Landing to Delta, a distance of 25 miles.

A line of precise levels was carried by Assistant Engineer L. L. Wheeler from Austin to Friar's Point, a distance of 34 miles. It has been found in the Swiss levelings of precision that different results are obtained by levelings over the same line in opposite directions, and the settling of the point on which the foresight is made, in the interval of time between the foresight and the backsight, was assigned as a cause. An investigation at some special points failed to detect such settlement, but the levels of last winter, which were run in both directions, give almost constantly a difference which would be produced by such a settling. In 43 kilometers the accumulated difference was $36^{mm}.3$. The mean result should be nearly free from the error.

In the latter part of January the river rose to 28 feet on the Memphis gauge, interfering with the work, but afterwards fell again. Owing to the late disappearance of the yellow fever and the unusually severe winter which partially or entirely closed the navigation of the river by running ice, thus interfering with the work for about three weeks, the progress was less rapid than had been hoped. The parties were withdrawn early in March.

A party under Assistant Engineer J. B. Johnson was left at Helena, Ark., to determine cross-sections and sediment for the Mississippi Board of Engineers. This party returned to Detroit on June 25, 1879, as the appropriation for the work was nearly exhausted. The most interesting result of the work of this party is the fact that at Helena, in water varying from 13 to 30 feet in depth, a series of sand waves was moving down stream on the bed of the river at an average rate of 18 feet a day, between March 9 and June 17, 1879. These waves have an average length, counted from crest to crest, of about 330 feet, and an extreme length of about 500 feet.

From valley to crest they have an average height of about 5 feet, and an extreme height of 8 feet. During the period of observation the stage of the river varied between 12 and 18 feet above low-water at Helena. The existence of sand waves of so large dimensions, and moving with such a velocity, does not seem to have been observed before on the Lower Mississippi. Their thorough study, continued during all stages of the river, may give important information about the conditions for low-water navigation.

### MISCELLANEOUS.

Maj. F. U. Farquhar desiring the determination of the positions of certain points connected with his surveys, Capt. H. M. Adams and First Lieut. C. F. Powell were assigned, in September, 1878, to this duty Captain Adams observed at Detroit in connection with Lieutenant Powell at Louisiana, Mo., Rock Island, Ill., and Red Wing, Minn., for longitude, by the telegraphic method, while Lieutenant Powell observed also for latitude and the magnetic elements.

The observations of the water-levels of the lakes has been continued at Sacket's Harbor and Charlotte, N. Y.; at Erie, Pa.; at Cleveland, Ohio; at Detroit, Port Austin, Sault Ste. Marie, Marquette, and Escanaba, Mich.; and at Milwaukee, Wis.

### OFFICE WORK.

The plotting of the field work of the Mississippi River survey below Memphis, done during the winter of 1877–'78, has been completed, and the plotting of the field work during the winter of 1878–'79 has been begun.

The computations of the secondary base-line at Harbert's Point, Miss., of the observations for the azimuth of that base, and of the triangulations executed in the winter of 1878–'79, have been completed.

The longitude, latitude, and magnetic work of Capt. H. M. Adams and Lieut. C. F. Powell has been computed.

The adjustment of the primary triangulation on Lake Erie, from line Chester-Willoughby to line Cedar Point-Stoney Point, has been completed, and the adjustment of the section at the south end of Lake Michigan, between the lines Fremont—Deerfield and Bald Tom—Michigan City, is about two-thirds done. These adjustments have been made by Assistant Engineers Kummell, Wright, and Russell.

Comparisons of each meter of tube 2 of the Repsold base apparatus have been made with the standard meter "R, 1876," at low temperature. The determination of the subdivisions of the meter "R, 1876," needed for comparisons with the Clarke yard "A," are nearly completed, and comparisons with that yard at low temperatures have been made.

Comparisons for determining the constants of the tubes have been continued.

A partial reduction of the measurement of the Sandusky base has been made.

Baudin Thermometer 6131 has had its errors of calibration determined and has been compared at various temperatures with other thermometers of the lake survey by Assistant Engineer Russell. The results show that the errors of the lake survey standards are as well known as is practicable without comparisons with a gas thermometer.

The preparation of the final report of the lake survey has been begun; and the first part, which includes the triangulation between the Keweenaw and Minnesota Point bases, is nearly ready for the printer.

The following-named charts have been completed and photolithographed:

Coast Chart No. 3, Lake Ontario, from Big Sodus Bay to Genesee River; scale 1:80,000, reduced by Mr. Max Franke.

Coast Chart No. 4, Lake Ontario, from Charlotte to Thirty-Mile Point; scale 1:80,000, reduced by Mr. A. de Witzleben.

Coast Chart No. 5, Lake Ontario, from Thirty-Mile Point to Port Dalhousie; scale 1:80,000, reduced by Mr. William A. Wansleben.

Coast Chart No. 2, Lake Erie, from Dunkirk to vicinity of Erie; scale 1:80,000, reduced by Mr. Max Franke.

Coast Chart No. 3, Lake Erie, from Erie to Conneaut, scale of 1:80,000, reduced by Mr. A. de Witzleben.

Coast Chart No. 4, Lake Erie, from Conneaut to Fairport, scale 1:80,000, has been completed by Mr. Max Franke, but is not yet photolithographed.

Charts Nos. 8, 9, 10, and 11 of the Mississippi River, south of Memphis, Tenn., have been completed. Nos. 8 and 9 have been photolithographed.

The new chart of Lake Erie, scale 1: 400,000, and coast charts Nos. 5 and 6 of Lake Erie, scale 1:80,000, are now in the hands of the draughtsmen.

The following table gives a résumé of the field work done between May 1, 1878, and June 30, 1879:

| | |
|---|---|
| Longitudes determined telegraphically | 3 |
| Latitudes determined | 3 |
| Primary triangulation stations occupied | 27 |
| Secondary triangulation stations occupied | 60 |
| Miles of developed shore-line | 197 |
| Square miles of topography | 104 |
| Square miles of river hydrography | 57 |
| Antiquarian sheets of topography and river hydrography plotted during the winter. | 8 |
| Miles of precise leveling in duplicate | 27 |
| Secondary azimuths determined | 1 |
| Primary base-line measured | 1 |
| Secondary base-line measured | 1 |

The results of astronomical work by Captain Adams and Lieutenant Powell are given in Appendix No. 1. The results of Lieutenant Powell's magnetic work are given in Appendix No. 2.

Lieutenant Lockwood's report on work on the Mississippi River is given in Appendix No. 3. Reports of chiefs of parties are given in Appendix No. 4.

A report on the measurement of the Sandusky base, by Assistant Engineer E. S. Wheeler, is given in Appendix No. 5.

A report on the levels of precision near Helena, Ark., by Assistant Engineer L. L. Wheeler, is given in Appendix No. 6.

A report on some constants of Troughton and Simms Theodolite No. 3, by Assistant Engineer R. S. Woodward, is given in Appendix No. 7.

A report on the errors of certain thermometers, by Assistant Engineer Thomas Russell, is given in Appendix No. 8.

The results of water-level observations on the lakes are given by Assistant Engineer A. R. Flint in Appendix No. 9.

Some results of sand wave and sediment observations are given in Appendix No. 10, by Assistant Engineer J. B. Johnson.

Lists of the published charts of the Lake Survey and of the Mississippi River, of the number of charts issued in different years, and of tracings furnished, are given in Appendix No. 11.

Sketches are forwarded herewith, showing the general progress of the Lake Survey, and of the Mississippi River survey.

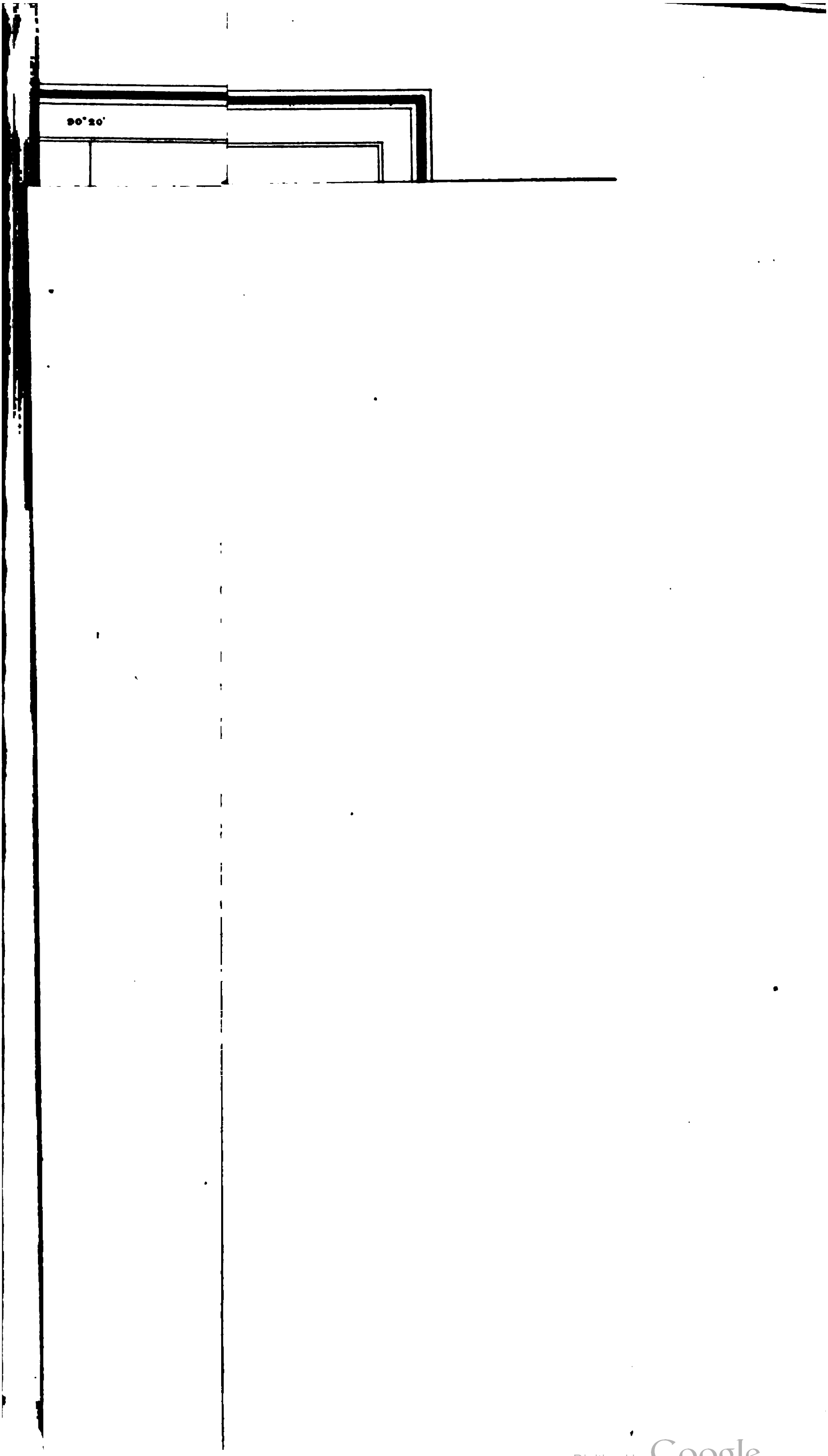
The following officers have continued on duty on the Survey of the Northern and Northwestern Lakes and Mississippi River:

Capt. H. M. Adams, till December 31, 1878, when he was relieved.
First Lieut. D. W. Lockwood, during the year.
First Lieut. C. F. Powell, till March 18, 1879, when he was relieved.
First Lieut. P. M. Price, during the year.

### *Financial.*

| | |
|---|---|
| Amount available July 1, 1878 | $99,000 00 |
| Amount expended in fiscal year ending June 30, 1879 | 89,942 25 |
| Amount available for lake survey July 1, 1879 | 85,000 00 |
| Amount required for fiscal year ending June 30, 1881, for lake survey | 44,800 00 |
| For Mississippi River survey | 158,660 00 |

79


30°20'

*Estimate of funds for continuance of Surveys of Northern and Northwestern Lakes and Mississippi River for the fiscal year ending June 30,* 1881.

| | |
|---|---|
| For the reduction of the field work of the lake survey, for the preparation and publication of the final report, for printing charts for the use of navigators, for continuance of water-level observations, for aid to State surveys, and miscellaneous | $44,800 00 |
| For continuing the survey of the Mississippi River and its tributaries with a view of determining the proper method of reclaiming from overflow the alluvial lands of the Mississippi delta, and improving the navigation of the river | 158,660 00 |

Details as follows:

### LAKE SURVEY.

| | |
|---|---|
| Completion of reduction of field-work | $16,400 |
| Preparation and publication of final report | 11,100 |
| Water-level observations and reductions | 2,500 |
| Printing and issuing charts for use of navigators | 3,300 |
| Office rent, clerk, watchmen, officers' quarters, and fuel and miscellaneous | 6,500 |
| Aid to State surveys | 5,000 |
| | 44,800 |

### SURVEY OF MISSISSIPPI RIVER.

| | |
|---|---|
| Six topographical, three triangulation and four leveling parties; field-work | $75,240 |
| Reduction of work | 17,640 |
| Printing maps | 8,400 |
| Clerk hire, office rent, watchmen, instruments, transportation, and miscellaneous | 17,180 |
| One stern-wheel steamer | 12,000 |
| Six large quarter-boats and outfit, at $4,200 each | 25,200 |
| Two small quarter-boats and outfit, at $1,500 each | 3,000 |
| | 158,660 |

Very respectfully, your obedient servant,

C. B. COMSTOCK,
*Major of Engineers, Bvt. Brig. Gen'l.*

The CHIEF OF ENGINEERS, U. S. A.

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## APPENDIX No. 1.

## TELEGRAPHIC LONGITUDE.

### REPORT ON TELEGRAPHIC LONGITUDE WORK IN CONNECTION WITH THE LAKE SURVEY OBSERVATORY, 1878, BY CAPTAIN H. M. ADAMS, CORPS OF ENGINEERS.

The longitudes of the following points have been determined in connection with the survey of the Mississippi River by Maj. F. U. Farquhar:

1. Rock Island, Ill.
2. Red Wing, Minn.
3. Louisiana, Mo.

Observations were made at Detroit by Capt. H. M. Adams and Assistant Engineer A. R. Flint. The following instruments were used: Transit instrument, made by Buff and Berger, having a focal length of 39 inches; magnifying power of telescope with diagonal eyepiece, 87, aperture 3 inches; Clock No. 256 and Chronograph No. 216, made by Bond & Sons; Lieut. C. F. Powell was the field observer. Signals were exchanged with Detroit on two nights for each of the stations occupied, Rock Island, Red Wing, and Louisiana.

The method of exchanging signals was by automatic clock and chronometer beats, which were recorded on a chronograph.

A complete time determination was made by each observer, before and after telegraphic signals. The time occupied for signals was generally about twenty-five minutes. In each time determination two stars of between 80° and 90° declination were observed and the telescope was reversed on each of these stars so as to obtain seven observations before and seven after reversal; ten or more time stars were observed on fifteen threads, one-half of the stars with telescope direct, and the other half with the telescope reversed.

### PROGRAMME FOR TIME DETERMINATION.

Level readings.
A circumpolar star, seven threads, telescope direct and reversed.
Level readings.
Five or more well determined time stars.
Level readings.
Reversal.
Level readings.
Five or more well determined time stars.
Level readings.
A circumpolar star, seven threads, telescope direct and reversed.
Level readings.

Level readings were also taken between the time stars when the interval of time was sufficient.

Observations were made for relative personal equation of Captain Adams and Lieutenant Powell, on four nights in 1877, and on two nights in 1878 after the completion of fieldwork. These observations were made in exactly the same manner as for determining longitude; Lieutenant Powell's transit instrument being mounted on a stone pier in the yard near the Lake Survey Observatory, and $0^s.005$ west of the Detroit transit instrument used by Captain Adams. The mean results for personal equation for season of 1877 and season of 1878 only differed $0^s.02$ (see Table 20). The mean of the six results was adopted and applied in computing the longitudes for season of 1878.

### EXPLANATION OF TABLES.

#### I.—*Tables* 1 *to* 16, *inclusive*.

Computation of time determination by method of high and low stars. "D" indicates telescope direct; "R" indicates telescope reversed; $t =$ the observed time of transit, the mean from 11 thread for time stars, and mean for all threads, reduced to middle thread for slow stars.

$A =$ the azimuth factor.
$B =$ the inclination factor.
$C =$ the collimation factor.
$a =$ the azimuth of transit instrument as computed from high and low stars.
$b =$ the inclination of the rotation axis.
$c =$ the collimation constant as computed from reversals on slow stars.
$\Delta\, i =$ constant for reduction to middle thread from mean of 11 threads.
$a\, b\, r =$ the correction for diurnal aberration $= 0^s.021$ cos. latitude.
$\alpha =$ the right ascension.
$\Delta\, t =$ the clock correction at corrected time of transit.
$r =$ the interval in clock hours, for which the rate $\rho$ is applied.
$\rho =$ the rate per clock-hour (+ when losing, — when gaining).
$\Delta\, t_0 =$ the clock-correction at a given epoch (+ when slow, — when fast).

The right ascensions were determined from American Ephemeris, 1878, German Catalogue, 539 stars, 1878, and General Bericht Europäische Gradmessung, 1873.

#### II.—*Tables* 17 *to* 20.

Telegraphic comparisons of clock and chronometer for determination of longitude and for relative personal equation of observers.

Each result is a mean from 15 ticks as registered by both time-pieces on a chronograph.

The chronograph readings for a single result from 15 ticks, sent from Red Wing to Detroit, are given below:

| | RED WING. | | | DETROIT. | | |
|---|---|---|---|---|---|---|
| | Chronometer No. 1541. | | | Clock No. 256. | | |
| | h. | m. | s. | h. | m. | s. |
| 1. | 0 | 29 | 01.00 | 1 | 18 | 07.38 |
| 2. | 0 | 29 | 02.00 | 1 | 18 | 08.40 |
| 3. | 0 | 29 | 03.00 | 1 | 18 | 09.40 |
| 4. | 0 | 29 | 04.00 | 1 | 18 | 10.38 |
| 5. | 0 | 29 | 05.00 | 1 | 18 | 11.40 |
| 6. | 0 | 29 | 06.00 | 1 | 18 | 12.38 |
| 7. | 0 | 29 | 07.00 | 1 | 18 | 13.38 |
| 8. | 0 | 29 | 08.00 | 1 | 18 | 14.38 |
| 9. | 0 | 29 | 09.00 | 1 | 18 | 15.38 |
| 10. | 0 | 29 | 10.00 | 1 | 18 | 16.38 |
| 11. | 0 | 29 | 11.00 | 1 | 18 | 17.38 |
| 12. | 0 | 29 | 12.00 | 1 | 18 | 18.39 |
| 13. | 0 | 29 | 13.00 | 1 | 18 | 19.38 |
| 14. | 0 | 29 | 14.00 | 1 | 18 | 20.38 |
| 15. | 0 | 29 | 15.00 | 1 | 18 | 21.38 |
| Means | 0 | 29 | 08.000 | 1 | 18 | 14.385 |

III.—*Table* 21.

Tabulated results for latitude and longitude. The observations for latitude were made by Lieut. C. F. Powell.

All computations have been made in duplicate and have been carefully checked.

H. M. ADAMS.

WASHINGTON, *May* 14, 1879.

TABLE 1.—*Time results, Detroit, September 26, 1878.—H. M. Adams, observer.*

| Tel. | Star. | t | Aa | Bb | C (c+Δi+abr) | α | Δt | rρ | Δt₀ |
|---|---|---|---|---|---|---|---|---|---|
| | | h. m. s. | s. | s. | s. | h. m. s. | h. m. s. | s. | h. m. s. |
| R. | 1 Draconis, L. C | 21 20 00.16 | − 0,11 | + 0,23 | 0.82 | 9 19 38.16 | − 0 00 22.94 | − 0.11 | − 0 00 22.83 |
| D. | 1 Draconis, L. C | 21 20 01.56 | − 0.11 | + 0.06 | − 0.60 | 9 19 38.16 | 22.75 | − 0.11 | 22.64 |
| D. | ξ Aquarii | 21 31 42.90 | − 0.01 | + 0.01 | + 0.07 | 21 31 19.51 | 23.46 | − 0.10 | 23.36 |
| D. | ε | 21 38 38.75 | − 0.01 | 0.01 | + 0.07 | 21 38 15.50 | 23.32 | − 0.09 | 23.23 |
| D. | Pegasi | 21 55 36.06 | − 0.01 | 0.00 | + 0.07 | 21 55 12.62 | 23.50 | − 0.08 | 23.42 |
| D. | Aquarii | 21 59 58.54 | − 0.01 | − 0.01 | 0.07 | 21 59 35.12 | 23.47 | − 0.08 | 23.39 |
| D. | Pegasi | 22 04 30.03 | − 0.01 | 0.01 | 0.07 | 22 04 06.74 | 23.34 | − 0.08 | 23.26 |
| D. | Aquarii | 22 10 51.33 | − 0.01 | 0.02 | + 0.07 | 22 10 27.97 | 23.40 | − 0.07 | 23.33 |
| | γ Aquarii | 22 15 49.09 | − 0.01 | 0.00 | − 0.10 | 22 15 25.43 | 23.55 | − 0.07 | 23.48 |
| | π Aquarii | 22 19 30.51 | − 0.01 | 0.00 | − 0.10 | 22 19 06.88 | 23.52 | − 0.07 | 23.45 |
| | η Aquarii | 22 29 32.91 | − 0.01 | 0.00 | − 0.10 | 22 29 09.36 | 23.44 | − 0.06 | 23.38 |
| D. | ζ Pegasi | 22 35 50.18 | − 0.01 | + 0.01 | − 0.11 | 22 35 26.61 | 23.46 | − 0.06 | 23.40 |
| D. | | 22 41 06.85 | 0.01 | + 0.01 | − 0.11 | 22 40 43.28 | 23.46 | − 0.05 | 23.41 |
| D. | Pegasi | 22 44 34.39 | − 0.01 | − 0.01 | − 0.11 | 22 44 10.85 | 23.41 | − 0.05 | 23.36 |
| D. | λ Aquarii | 22 46 42.86 | − 0.01 | 0.01 | − 0.11 | 22 46 19.19 | 23.54 | − 0.05 | 23.49 |
| | Carr. 3525 | 22 55 49.76 | 0.11 | − 0.49 | − 1.06 | 22 55 25.51 | 23.11 | − 0.04 | 23.07 |
| D. | Carr. 3525 | 22 55 47.31 | + 0.11 | − 0.33 | + 0.78 | 22 55 25.51 | 22.66 | − 0.04 | 22.62 |
| D. | α Urs. Min | 1 15 17.69 | + 0.59 | − 0.36 | + 3.66 | 1 14 58.58 | 23.00 | 0.05 | 23.05 |
| D. | α Urs. Min | 1 15 27.31 | + 0.59 | − 3.73 | − 5.00 | 1 14 58.58 | 20.59 | + 0.05 | 20.64 |
| D. | β Arietis | 1 48 22.09 | − 0.01 | − 0.10 | − 0.11 | 1 47 58.50 | 23.37 | 0.07 | 23.34 |
| D. | edæ | 1 56 53.24 | 0.00 | − 0.12 | − 0.14 | 1 56 29.75 | 23.23 | + 0.07 | 23.30 |
| D. | α [illegible] | 2 00 45.83 | − 0.01 | − 0.09 | − 0.11 | 2 00 22.30 | 23.32 | + 0.08 | 23.40 |
| D. | γ Trianguli | 2 10 32.09 | 0.00 | − 0.13 | − 0.12 | 2 10 08.51 | 23.33 | + 0.08 | 23.41 |
| D. | ο Ceti | 2 13 38.60 | − 0.01 | − 0.07 | − 0.10 | 2 13 15.14 | 23.28 | 0.09 | 23.37 |
| D. | | 2 22 07.95 | − 0.01 | − 0.08 | + 0.07 | 2 21 44.61 | 23.32 | + 0.09 | 23.41 |
| D. | | 2 37 26.10 | − 0.01 | − 0.05 | + 0.07 | 2 37 02.89 | 23.22 | + 0.10 | 23.32 |
| D. | 41 Arietis | 2 43 16.02 | − 0.01 | − 0.05 | + 0.08 | 2 42 52.75 | 23.29 | + 0.10 | 23.39 |
| D. | | 2 50 55.28 | − 0.01 | − 0.03 | + 0.07 | 2 50 32.02 | 23.29 | 0.11 | 23.40 |
| D. | | 2 56 21.46 | − 0.01 | − 0.06 | + 0.07 | 2 55 58.21 | 23.25 | + 0.11 | 23.36 |
| D. | Carr. 491 | 3 27 33.69 | 0.20 | − 1.18 | + 1.31 | 3 27 10.63 | 23.39 | + 0.13 | 23.52 |
| | Carr. 491 | 3 27 37.35 | + 0.20 | − 1.17 | − 1.79 | 3 27 10.63 | 23.96 | + 0.13 | 24.09 |

| | s. |
|---|---|
| From 1 Draconis, | c = + 0.087, tel. direct. |
| Carr. 3525, | c = + 0.125, tel. direct. |
| α Urs. Min., | c = + 0.073, tel. direct. |
| Carr. 491, | c = + 0.120, tel. direct. |
| Mean .... | c = + 0.101, tel. direct. |

s.
a = + 0.088
a = − 0.116
a = − 0.068
a = + 0.019

Mean...... a = − 0.019

Mean $\Delta t_0$ (excluding high stars) = − 23ˢ.381 at 24ʰ. 04 clock time.
$\rho$ = + 0ˢ.0393, losing.

TABLE 2.—*Time results, Detroit, September 30, 1878.—H. M. Adams, observer.*

| Tel. | Star. | t | Aa | b | Δi+abr) | | Δt | r | $t_0$ |
|---|---|---|---|---|---|---|---|---|---|
| | | h. m. s. | s. | s. | s. | h. m. s. | h. m. s. | s. | h. m. s. |
| R. | 1 Draconis, L. C | 21 20 00.58 | − 1.57 | + 0.24 | + 1.00 | 9 19 38.66 | − 0 00 21.59 | + 0.01 | − 0 00 21.60 |
| D. | 1 Draconis, L. C | 21 20 02.68 | − 1.57 | 0.12 | − 0.78 | 9 19 38.66 | 21.79 | + 0.01 | 21.80 |
| D. | ξ Aquarii | 21 31 41.64 | − 0.21 | + 0.01 | + 0.10 | 21 31 19.47 | 22.07 | + 0.01 | 22.08 |
| D. | ε Pegasi | 21 38 37.41 | − 0.15 | + 0.01 | + 0.10 | 21 38 15.46 | 21.91 | + 0.01 | 21.92 |
| D. | μ Capricorni | 21 47 05.03 | − 0.23 | 0.00 | + 0.10 | 21 46 42.92 | 21.98 | + 0.01 | 21.99 |
| D. | 20 Pegasi | 21 55 34.62 | − 0.14 | 0.00 | + 0.10 | 21 55 12.59 | 21.99 | + 0.01 | 22.00 |
| D. | α Aquarii | 21 59 57.20 | − 0.18 | 0.01 | + 0.10 | 21 59 35.09 | 22.04 | 0.00 | 22.04 |
| D. | θ Pegasi | 22 04 28.78 | − 0.16 | 0.00 | + 0.10 | 22 04 06.71 | 22.01 | 0.00 | 22.01 |
| D. | θ Aquarii | 22 10 50.07 | − 0.21 | 0.00 | + 0.10 | 22 10 27.95 | 22.01 | 0.00 | 22.01 |
| R. | γ Aquarii | 22 15 47.80 | − 0.19 | 0.00 | − 0.13 | 22 15 25.41 | 22.07 | 0.00 | 22.07 |
| R. | π Aquarii | 22 19 29.27 | − 0.18 | 0.01 | − 0.13 | 22 19 06.86 | 22.11 | 0.00 | 22.11 |
| R. | η Aquarii | 22 29 31.77 | − 0.18 | − 0.01 | − 0.13 | 22 29 09.34 | 22.11 | 0.00 | 22.11 |
| R. | Pegasi | 22 35 49.04 | − 0.14 | − 0.01 | − 0.13 | 22 35 26.59 | 22.17 | 0.00 | 22.17 |
| R. | λ Pegasi | 22 41 05.55 | − 0.10 | − 0.01 | − 0.14 | 22 40 43.26 | 22.04 | 0.00 | 22.04 |
| R. | μ Pegasi | 22 44 33.21 | − 0.09 | − 0.01 | − 0.14 | 22 44 10.84 | 22.13 | 0.00 | 22.13 |
| R. | Aquarii | 22 46 41.71 | − 0.21 | − 0.00 | − 0.13 | 22 46 19.18 | 22.19 | 0.00 | 22.19 |
| R. | Carr. 3525 | 22 55 47.18 | + 1.61 | − 0.49 | 1.29 | 22 55 24.92 | 22.09 | 0.00 | 22.09 |
| D. | Carr. 3525 | 22 55 44.35 | + 1.61 | − 0.27 | + 1.01 | 22 55 24.92 | 21.78 | 0.00 | 21.78 |
| D. | Urs. Min | 1 15 08.41 | + 8.31 | 0.21 | + 4.73 | 1 15 00.13 | 21.11 | 0.00 | 21.11 |
| R. | α Urs. Min | 1 15 19.69 | + 8.31 | − 2.13 | − 6.07 | 1 15 00.13 | 19.67 | 0.00 | 19.67 |
| R. | β Arietis | 1 48 20.90 | − 0.11 | + 0.02 | − 0.14 | 1 47 58.56 | 22.11 | 0.00 | 22.11 |
| R. | γ Andromedæ | 1 56 51.94 | − 0.00 | 0.01 | − 0.17 | 1 56 29.84 | 21.94 | 0.00 | 21.94 |
| R. | α Arietis | 2 00 44.61 | − 0.10 | 0.00 | − 0.14 | 2 00 22.37 | 22.00 | 0.00 | 22.00 |
| R. | Ceti | 2 06 58.75 | − 0.15 | 0.00 | − 0.18 | 2 06 36.30 | 22.17 | 0.00 | 22.17 |
| R. | γ Trianguli | 2 10 30.89 | 0.05 | 0.00 | − 0.15 | 2 10 08.59 | 22.10 | 0.00 | 22.10 |
| R. | ο Ceti | 2 13 37.65 | − 0.19 | 0.00 | 0.13 | 2 13 15.20 | 22.13 | 0.00 | 22.13 |
| D. | Ceti | 2 22 06.70 | − 0.15 | 0.03 | + 0.10 | 2 21 44.68 | 22.00 | 0.01 | 21.99 |
| D. | ν Arietis | 2 32 19.91 | − 0.10 | + 0.04 | + 0.11 | 2 31 57.88 | 22.08 | 0.01 | 22.07 |
| D. | Ceti | 2 37 25.06 | − 0.17 | 0.04 | + 0.10 | 2 37 02.97 | 22.06 | − 0.01 | 22.05 |
| D. | 41 Arietis | 2 43 14.81 | − 0.08 | 0.06 | + 0.11 | 2 42 52.84 | 22.06 | 0.01 | 22.05 |
| D. | η Eridani | 2 50 54.16 | − 0.21 | 0.03 | + 0.10 | 2 50 32.10 | 21.98 | − 0.01 | 21.97 |
| D. | Ceti | 2 56 20.41 | 0.17 | 0.03 | 0.10 | 2 55 58.30 | 22.07 | − 0.01 | 22.06 |
| D. | Carr. 491 | 3 27 30.11 | 2.85 | − 0.13 | 1.69 | 3 27 11.85 | 22.67 | − 0.01 | 22.67 |
| R. | Carr. 491 | 3 27 34.39 | 2.85 | − 1.03 | 2.17 | 3 27 11.85 | 22.19 | − 0.01 | 22.19 |

s. s.

From 1 Draconis, $c=+0.140$ $a=-0.220$

Carr. 3525, $c=+0.143$ $a=-0.298$

α Urs. Min., $c=+0.109$ $a=-0.323$

Carr. 491, $c=+0.110$ $a=-0.232$

Mean...... $c=+0.126$ tel. direct. Mean...... $a=-0.268$

Mean $\Delta t_0$ (excluding high stars) $=-22^s.060$ at $24^h.13$ clock time.

$\rho=-\ 0^s.0024$ gaining.

TABLE 3.—*Time results, Detroit, October 24, 1878.—H. M. Adams, observer.*

| Tel. | Star. | $t$ | A$a$ | B$b$ | C$(c+\Delta i+abr)$ | $a$ | $\Delta t$ | $r\rho$ | $\Delta t_0$ |
|---|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *h. m. s.* | *s.* | *h. m. s.* |
| R. | 1 Draconis, L. C | 21 19 50.66 | − 1.72 | + 0.25 | + 0.62 | 9 19 42.36 | − 0 00 07.45 | − 0.09 | − 0 00 07.36 |
| D. | 1 Draconis, L. C | 21 19 52.17 | − 1.72 | + 0.03 | − 0.40 | 9 19 42.36 | 07.72 | − 0.09 | 07.63 |
| D. | ξ Aquarii | 21 31 27.38 | − 0.23 | + 0.01 | + 0.05 | 21 31 19.19 | 08.02 | − 0.09 | 07.93 |
| D. | ε Pegasi | 21 38 23.17 | − 0.16 | + 0.02 | + 0.05 | 21 38 15.18 | 07.90 | − 0.08 | 07.82 |
| D. | μ Capricorni | 21 46 50.87 | − 0.25 | 0.00 | + 0.05 | 21 46 42.66 | 08.01 | − 0.08 | 07.93 |
| D. | 20 Pegasi | 21 55 20.40 | − 0.15 | + 0.03 | + 0.05 | 21 55 12.33 | 08.00 | − 0.08 | 07.92 |
| D. | α Aquari | 21 59 42.90 | − 0.20 | + 0.03 | + 0.04 | 21 59 34.84 | 07.93 | − 0.07 | 07.86 |
| D. | θ Pegasi | 22 04 14.51 | − 0.18 | + 0.04 | + 0.05 | 22 04 06.48 | 07.94 | − 0.07 | 07.87 |
| D. | θ Aquarii | 22 10 35.78 | − 0.23 | + 0.02 | + 0.05 | 22 10 27.71 | 07.91 | − 0.07 | 07.84 |
| R. | Aquarii | 22 15 33.49 | − 0.21 | + 0.01 | − 0.07 | 22 15 25.19 | 08.03 | − 0.06 | 07.97 |
| R. | π Aquarii | 22 19 14.92 | − 0.19 | + 0.01 | − 0.08 | 22 19 06.65 | 08.01 | − 0.06 | 07.95 |
| R. | ζ Pegasi | 22 35 34.70 | − 0.16 | + 0.03 | − 0.08 | 22 35 26.40 | 08.09 | − 0.05 | 08.04 |
| R. | Pegasi | 22 40 51.13 | − 0.11 | + 0.04 | − 0.08 | 22 40 43.06 | 07.92 | − 0.05 | 07.87 |
| R. | μ Pegasi | 22 44 18.74 | − 0.10 | + 0.01 | − 0.08 | 22 44 10.64 | 07.93 | − 0.05 | 07.88 |
| R. | λ Aquarii | 22 46 27.34 | − 0.23 | 0.00 | − 0.08 | 22 46 19.02 | 08.01 | − 0.05 | 07.96 |
| R. | Carr. 3525 | 22 55 29.22 | + 1.78 | − 0.07 | − 0.80 | 22 55 22.31 | 07.82 | − 0.04 | 07.78 |
| D. | Carr. 3525 | 22 55 28.05 | + 1.78 | − 0.08 | + 0.52 | 22 55 22.31 | 07.96 | − 0.04 | 07.92 |
| | | | | | | | | | |
| D. | α Urs. Min | 1 14 58.16 | + 9.17 | − 0.53 | + 2.42 | 1 15 02.36 | 06.86 | + 0.03 | 06.89 |
| R. | α Urs. Min | 1 15 03.93 | + 9.17 | − 1.19 | − 3.76 | 1 15 02.36 | 05.79 | + 0.03 | 05.82 |
| R. | o Piscium | 1 39 09.81 | − 0.16 | + 0.02 | − 0.08 | 1 39 01.76 | 07.83 | + 0.04 | 07.87 |
| R. | α Trianguli | 1 46 20.66 | − 0.08 | + 0.02 | − 0.09 | 1 46 12.66 | 07.85 | + 0.05 | 07.90 |
| R. | β Arietis | 1 48 06.91 | − 0.12 | - 0.01 | − 0.08 | 1 47 58.84 | 07.86 | + 0.05 | 07.91 |
| R. | γ Andromedæ | 1 56 38.17 | 0.00 | - 0.01 | − 0.10 | 1 56 30.20 | 07.86 | + 0.05 | 07.91 |
| R. | Arietis | 2 00 30.66 | − 0.11 | + 0.03 | − 0.08 | 2 00 22.68 | 07.82 | + 0.05 | 07.87 |
| R. | Ceti | 2 06 44.77 | − 0.17 | + 0.02 | − 0.08 | 2 06 36.60 | 07.94 | + 0.06 | 08.00 |
| R. | γ Trianguli | 2 10 16.93 | − 0.06 | + 0.02 | − 0.09 | 2 10 08.97 | 07.83 | + 0.06 | 07.89 |
| R. | o Ceti | 2 13 23.63 | − 0.21 | + 0.01 | − 0.08 | 2 13 15.52 | 07.83 | + 0.06 | 07.89 |
| D. | ξ² Ceti | 2 21 52.93 | − 0.17 | + 0.01 | + 0.05 | 2 21 45.02 | 07.80 | + 0.07 | 07.87 |
| D. | ν Arietis | 2 32 06.34 | − 0.11 | + 0.02 | + 0.05 | 2 31 58.28 | 08.02 | + 0.07 | 08.09 |
| D. | γ Ceti | 2 37 11.22 | − 0.19 | + 0.02 | + 0.04 | 2 37 03.34 | 07.75 | + 0.07 | 07.82 |
| D. | 41 Arietis | 2 44 01.08 | − 0.09 | + 0.04 | + 0.05 | 2 42 53.28 | 07.80 | + 0.08 | 07.88 |
| D. | η Eridani | 2 50 40.51 | − 0.23 | + 0.02 | + 0.05 | 2 50 32.50 | 07.85 | + 0.08 | 07.93 |
| D. | α Ceti | 2 56 06.60 | − 0.18 | + 0.03 | + 0.04 | 2 55 58.72 | 07.77 | + 0.08 | 07.85 |

From 1 Draconis, $c = +0.091$ *s.*, tel. direct. $a = -0.227$ *s.*
α Urs. Min., $c = +0.059$, tel. direct. $a = -0.315$
Carr. 3525, $c = +0.065$, tel. direct. $a = -0.343$

Mean . . . . . $c = +0.072$, tel. direct. Mean . . . . . . $a = -0.295$

Mean $\Delta t_0$ (excluding high stars) $= -07^s.908$ at $24^h.30$ clock-time.
$\rho = +\ 0^s.0319$, losing.

TABLE 4.—*Time results, Detroit, October* 31, 1878.—*A. R. Flint, observer.*

| Tel. | Stars. | t. | Aa. | Bb. | C (c+Δi+a b r) | a | Δt | rp | Δt₀ |
|---|---|---|---|---|---|---|---|---|---|
| | | h. m. s. | s. | s. | s. | h. m. s. | h. m. s. | s. | h. m. s. |
| D | ξ Aquarii | 21 31 21.30 | — 0.14 | — 0.02 | 0.00 | 21 31 19.09 | — 0 00 02.05 | — 0.19 | — 0 00 01.86 |
| D. | θ Aquarii | 22 10 29.78 | — 0.14 | — 0.01 | 0.00 | 22 10 27.63 | 02.00 | — 0.16 | 01.84 |
| D. | γ Aquarii | 22 15 27.28 | — 0.13 | — 0.01 | 0.00 | 22 15 25.11 | 02.03 | — 0.16 | 01.87 |
| D | π Aquarii | 22 19 08.73 | — 0.12 | 0.00 | 0.00 | 22 19 06.57 | 02.04 | — 0.16 | 01.88 |
| R. | ζ Pegasi | 22 35 28.53 | — 0.10 | — 0.01 | — 0.03 | 22 35 26.32 | 02.07 | — 0.15 | 01.92 |
| R. | λ Pegasi | 22 40 45.07 | — 0.07 | — 0.01 | — 0.03 | 22 40 42.98 | 01.98 | — 0.14 | 01.84 |
| R. | λ Aquarii | 22 46 21.32 | — 0.14 | — 0.01 | — 0.03 | 22 46 18.95 | 02.19 | — 0.14 | 02.05 |
| R. | Carr. 3525 | 22 55 22.61 | + 1.09 | — 0.18 | — 0.40 | 22 55 21.30 | 01.82 | — 0.13 | 01.69 |
| D. | Carr. 3525 | 22 55 21.46 | + 1.09 | — 0.19 | + 0.12 | 22 55 21.30 | 01.18 | — 0.13 | 01.05 |
| D. | ξ¹ Ceti | 2 06 38.84 | — 0.10 | — 0.01 | 0.00 | 2 06 36.66 | 02.07 | + 0.02 | 02.09 |
| D. | γ Trianguli | 2 10 10.80 | — 0.03 | — 0.03 | 0.00 | 2 10 09.04 | 01.70 | + 0.02 | 01.72 |
| D. | ξ² Ceti | 2 21 46.96 | — 0.10 | — 0.03 | 0.00 | 2 21 45.09 | 01.74 | + 0.03 | 01.77 |
| D. | ν Arietis | 2 32 00.28 | — 0.07 | — 0.02 | 0.00 | 2 31 58.36 | 01.83 | + 0.04 | 01.87 |
| R. | γ Ceti | 2 37 05.44 | — 0.11 | — 0.01 | — 0.03 | 2 37 03.41 | 01.88 | + 0.05 | 01.93 |
| R. | 41 Arietis | 2 42 55.28 | — 0.05 | — 0.01 | — 0.03 | 2 42 53.38 | 01.81 | + 0.05 | 01.86 |
| R. | η Eridani | 2 50 34.59 | — 0.14 | — 0.01 | — 0.03 | 2 50 32.58 | 01.83 | + 0.06 | 01.89 |
| R. | α Ceti | 2 56 00.88 | — 0.11 | — 0.01 | — 0.03 | 2 55 58.81 | 01.92 | + 0.06 | 01.98 |
| R. | δ Arietis | 3 04 46.16 | — 0.07 | — 0.01 | — 0.03 | 3 04 44.21 | 01.84 | + 0.07 | 01.91 |
| R. | Carr. 491 | 3 27 20.21 | + 1.93 | — 0.30 | — 0.67 | 3 27 19.12 | 02.05 | + 0.08 | 02.13 |
| D. | Carr. 491 | 3 27 19.09 | + 1.93 | — 0.13 | + 0.19 | 3 27 19.12 | 01.96 | + 0.08 | 02.04 |
| D. | 27 Tauri | 3 42 01.61 | — 0.06 | — 0.02 | 0.00 | 3 41 59.66 | 01.87 | + 0.10 | 01.97 |
| D. | ζ Persei | 3 46 35.18 | — 0.04 | — 0.03 | 0.00 | 3 46 33.28 | 01.83 | + 0.10 | 01.93 |
| D. | ε Persei | 3 49 47.84 | — 0.01 | — 0.03 | 0.00 | 3 49 45.95 | 01.85 | + 0.11 | 01.96 |
| D. | Gr. 750 | 3 59 20.50 | + 1.48 | — 0.28 | + 0.16 | 3 59 19.48 | 02.38 | + 0.11 | 02.49 |
| R. | γ Tauri | 4 12 57.72 | — 0.09 | — 0.02 | — 0.03 | 4 12 55.94 | 01.64 | + 0.12 | 01.76 |
| R. | ε Tauri | 4 21 36.46 | — 0.08 | — 0.02 | — 0.03 | 4 21 34.56 | 01.77 | + 0.13 | 01.90 |
| R. | τ Tauri | 4 34 59.45 | — 0.07 | — 0.01 | + 2.83 | 4 34 60.45 | 01.75 | + 0.14 | 01.89 |
| R. | ε Urs. Min. L. C | 4 58 20.45 | — 1.09 | + 0.03 | + 0.32 | 16 58 17.71 | 02.00 | + 0.15 | 02.15 |
| D. | ε Urs. Min. L. C | 4 58 20.25 | — 1.09 | + 0.06 | — 0.10 | 16 58 17.71 | 01.41 | + 0.15 | 01.56 |

| | | s. | | s. |
|---|---|---|---|---|
| From Carr. | 3525, | c = + 0.064 | | a = — 0.275 |
| Carr. | 491, | c = + 0.031 | | a = — 0.168 |
| Gr. | 750, | ............ | | a = — 0.108 |
| ε Urs. Min. L. C., | | c = — 0.011 | | a = — 0.172 |
| Mean... | | c = + 0.028 tel. direct. | Mean...... | a = — 0.181 |

Mean Δ $t_0$ (excluding high stars) = — 01ˢ.895 at 1ʰ.64 clock-time.

ρ = + 0ˢ.046 losing.

TABLE 5.—*Time results, Detroit, November 13, 1878.—H. M. Adams, observer.*

| Tel. | Star. | t |  |  | A a | B b | C (c+Δi+abr) | α |  |  | Δt |  |  | rρ | Δt₀ |  |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | h. | m. | s. | s | s. | s. | h. | m. | s. | h. | m. | s. | s. | h. | m. | s. |
| R. | Carr. 3525 | 22 | 55 | 11.03 | − 1.25 | − 0.46 | − 0.75 | 22 | 55 | 19.17 | + 0 | 00 | 10.60 | + 0.01 | + 0 | 00 | 10.61 |
| D. | Carr. 3525 | 22 | 55 | 09.38 | − 1.25 | − 0.43 | + 0.47 | 22 | 55 | 19.17 |  |  | 11.00 | + 0.01 |  |  | 11.01 |
| D. | γ Piscium | 23 | 10 | 43.49 | + 0.13 | + 0.01 | + 0.04 | 23 | 10 | 54.39 |  |  | 10.72 | + 0.01 |  |  | 10.73 |
| D. | τ Pegasi | 23 | 14 | 28.92 | + 0.07 | 0.00 | + 0.04 | 23 | 14 | 39.73 |  |  | 10.70 | + 0.01 |  |  | 10.71 |
| D. | Pegasi | 23 | 46 | 10.25 | + 0.09 | − 0.01 | + 0.04 | 23 | 46 | 20.98 |  |  | 10.61 | + 0.01 |  |  | 10.62 |
| D. | ω Piscium | 23 | 52 | 56.17 | + 0.12 | − 0.01 | + 0.04 | 23 | 53 | 06.96 |  |  | 10.64 | + 0.01 |  |  | 10.65 |
| R. | α Andromedæ | 0 | 01 | 58.52 | + 0.06 | − 0.02 | − 0.08 | 00 | 02 | 09.12 |  |  | 10.64 | + 0.01 |  |  | 10.65 |
| R. | γ Pegasi | 0 | 06 | 50.85 | + 0.10 | − 0.03 | − 0.07 | 00 | 07 | 01.45 |  |  | 10.60 | + 0.01 |  |  | 10.61 |
| R. | ι Ceti | 0 | 13 | 06.27 | + 0.17 | − 0.02 | − 0.07 | 00 | 18 | 17.01 |  |  | 10.66 | + 0.01 |  |  | 10.67 |
| R. | 12 Ceti | 0 | 23 | 42.43 | + 0.15 | − 0.04 | − 0.07 | 00 | 23 | 53.08 |  |  | 10.61 | + 0.01 |  |  | 10.62 |
| R. | π Andromedæ | 0 | 30 | 15.92 | + 0.04 | − 0.07 | − 0.08 | 00 | 30 | 26.46 |  |  | 10.65 | 0.01 |  |  | 10.66 |
| R. | δ Andromedæ | 0 | 32 | 42.27 | + 0.05 | − 0.07 | − 0.08 | 00 | 32 | 52.85 |  |  | 10.68 | + 0.01 |  |  | 10.69 |
| R. | β Ceti | 0 | 37 | 21.63 | + 0.19 | − 0.03 | − 0.07 | 00 | 37 | 32.31 |  |  | 10.59 | + 0.01 |  |  | 10.60 |
| R. | α Urs. Min | 1 | 14 | 58.60 | − 6.47 | − 3.02 | − 3.55 | 01 | 14 | 58.52 |  |  | 12.96 | 0.00 |  |  | 12.96 |
| D. | α Urs. Min | 1 | 14 | 51.62 | − 6.47 | − 2.01 | + 2.21 | 01 | 14 | 58.52 |  |  | 13.17 | 0.00 |  |  | 13.17 |
| D. | Carr. 491 | 3 | 27 | 13.16 | − 2.22 | − 0.09 | + 0.79 | 03 | 27 | 20.77 |  |  | 09.13 | 0.00 |  |  | 09.13 |
| R. | Carr. 491 | 3 | 27 | 13.67 | − 2.22 | − 0.70 | − 1.27 | 03 | 27 | 20.77 |  |  | 11.29 | 0.00 |  |  | 11.29 |
| R. | ζ Persei | 3 | 46 | 22.85 | + 0.05 | − 0.01 | − 0.08 | 03 | 46 | 33.52 |  |  | 10.71 | − 0.01 |  |  | 10.70 |
| R. | $\gamma^1$ Eridani | 3 | 52 | 14.06 | + 0.18 | 0.00 | − 0.07 | 03 | 52 | 24.77 |  |  | 10.60 | − 0.01 |  |  | 10.59 |
| R. | λ Tauri | 3 | 53 | 49.63 | + 0.11 | 0.00 | − 0.07 | 03 | 54 | 00.32 |  |  | 10.65 | − 0.01 |  |  | 10.64 |
| R. | Tauri | 3 | 56 | 34.10 | + 0.12 | + 0.01 | − 0.07 | 03 | 56 | 44.89 |  |  | 10.73 | − 0.01 |  |  | 10.72 |
| D. | γ Tauri | 4 | 12 | 45.23 | + 0.10 | + 0.02 | + 0.04 | 04 | 12 | 56.18 |  |  | 10.79 | − 0.01 |  |  | 10.78 |
| D. | δ Tauri | 4 | 15 | 48.26 | + 0.09 | + 0.02 | + 0.04 | 04 | 15 | 59.17 |  |  | 10.76 | − 0.01 |  |  | 10.75 |
| D. | ε Tauri | 4 | 21 | 24.03 | + 0.09 | + 0.04 | + 0.04 | 04 | 21 | 34.81 |  |  | 10.61 | − 0.01 |  |  | 10.60 |
| D. | ν Eridani | 4 | 30 | 07.11 | + 0.15 | + 0.03 | + 0.04 | 04 | 30 | 18.01 |  |  | 10.68 | − 0.01 |  |  | 10.67 |
| D. | τ Tauri | 4 | 34 | 49.99 | + 0.07 | + 0.02 | + 0.04 | 04 | 34 | 60.72 |  |  | 10.60 | − 0.01 |  |  | 10.59 |
| D. | μ Eridani | 4 | 39 | 17.96 | + 0.15 | 0.00 | + 0.04 | 04 | 39 | 28.75 |  |  | 10.60 | − 0.01 |  |  | 10.59 |
| D. | Urs. Min., L. C | 4 | 58 | 04.63 | + 1.27 | + 0.18 | − 0.39 | 16 | 58 | 16.28 |  |  | 10.59 | − 0.01 |  |  | 10.58 |
| R. | Urs. Min., L. C | 4 | 58 | 02.81 | + 1.27 | + 0.33 | + 0.61 | 16 | 58 | 16.28 |  |  | 11.26 | − 0.01 |  |  | 11.25 |

| | s. | s. |
|---|---|---|
| From Carr. 3525, | $c = +0.089$, tel. direct. | $a = +0.187$ |
| α Urs. Min., | $c = +0.069$, tel. direct. | $a = +0.131$ |
| Carr. 491, | $c = -0.003$, tel. direct. | $a = +0.248$ |
| ε Urs. Min., | $c = +0.113$, tel. direct. | $a = +0.264$ |
| Mean..... | $c = +0.067$, tel. direct, | $a = +0.208$ |

Mean $\Delta t_0$ (excluding high stars) $= +10^s.659$ at $2^h.03$ clock-time.
$\rho = +0^s.0044$ losing.

TABLE 6.—*Time results, Detroit, November 19, 1878.—H. M. Adams, observer.*

| Tel. | Star. | *t* | | | A *a* | B *b* | C(c+Δi+*a b r*) | α | | | Δ*t* | | | *r*ρ | Δ*t*₀ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *s.* | *h.* | *m.* | *s.* |
| R. | Carr. 3525 | 22 | 55 | 07.04 | + 0.21 | + 0.62 | − 0.67 | 22 | 55 | 18.11 | + 0 | 00 | 10.91 | − 0.01 | + 0 | 00 | 10.90 |
| D. | Carr. 3525 | 22 | 55 | 07.44 | + 0.21 | + 0.75 | − 0.39 | 22 | 55 | 18.11 | | | 09.32 | − 0.01 | | | 09 31 |
| D. | γ Piscium | 23 | 10 | 44.54 | − 0.02 | + 0.15 | + 0.03 | 23 | 10 | 54.33 | | | 09.63 | − 0.01 | | | 09.62 |
| D. | τ Pegasi | 23 | 14 | 29.82 | − 0.01 | + 0.21 | + 0.03 | 23 | 14 | 39.66 | | | 09.61 | − 0.01 | | | 09.60 |
| D. | ν Pegasi | 23 | 19 | 11.39 | − 0.01 | + 0.21 | + 0.03 | 23 | 19 | 21.19 | | | 09.57 | − 0.01 | | | 09.56 |
| D. | θ um | 23 | 21 | 40.82 | − 0.02 | + 0.17 | + 0.03 | 23 | 21 | 50.62 | | | 09.62 | − 0.01 | | | 09.61 |
| D. | 72 Pegasi | 23 | 27 | 47.90 | − 0.01 | + 0.23 | + 0.04 | 23 | 27 | 57.87 | | | 09.71 | − 0.01 | | | 09.70 |
| D. | ι Piscium | 23 | 33 | 34.57 | − 0.02 | + 0.17 | + 0.03 | 23 | 33 | 44.56 | | | 09.81 | − 0.01 | | | 09.80 |
| D. | ψ Pegasi | 23 | 46 | 11.01 | − 0.02 | + 0.22 | + 0.03 | 23 | 46 | 20.92 | | | 09.68 | − 0.01 | | | 09.67 |
| D. | ω Piscium | 23 | 52 | 56.93 | − 0.02 | + 0.18 | + 0.03 | 23 | 53 | 06.91 | | | 09.79 | − 0.01 | | | 09.78 |
| R. | α Andromedæ | 0 | 01 | 59.29 | − 0.01 | + 0.21 | − 0.07 | 0 | 02 | 09.06 | | | 09.64 | − 0.01 | | | 09.63 |
| R. | γ Pegasi | 0 | 06 | 51.61 | − 0.02 | + 0.18 | − 0.06 | 0 | 07 | 01.40 | | | 09.69 | − 0.01 | | | 09.68 |
| R. | 12 Ceti | 0 | 23 | 43.42 | − 0.03 | + 0.13 | − 0.06 | 0 | 23 | 53.04 | | | 09.58 | − 0.01 | | | 09.57 |
| R. | π Andromedæ | 0 | 30 | 16.55 | − 0.01 | + 0.23 | − 0.07 | 0 | 30 | 26.41 | | | 09.71 | − 0.01 | | | 09.70 |
| R. | δ Andromedæ | 0 | 32 | 42.96 | − 0.01 | + 0.21 | − 0.07 | 0 | 32 | 52.80 | | | 09.71 | − 0.01 | | | 09.70 |
| R. | β Ceti | 0 | 37 | 22.67 | − 0.03 | + 0.10 | − 0.07 | 0 | 37 | 32.26 | | | 09.59 | − 0.01 | | | 09.58 |
| R. | α Urs. Min | 1 | 14 | 45.13 | + 1.09 | + 4.68 | − 3.21 | 1 | 14 | 55.67 | | | 07.98 | 0.00 | | | 07.98 |
| D. | α Urs. Min | 1 | 14 | 35.17 | + 1.09 | + 5.89 | + 1.87 | 1 | 14 | 55.67 | | | 11.65 | 0.00 | | | 11.65 |
| | | | | | | | | | | | | | | | | | |
| D. | γ Tauri | 4 | 12 | 46.31 | − 0.02 | + 0.21 | + 0.03 | 4 | 12 | 56.28 | | | 09.75 | + 0.01 | | | 09.76 |
| D. | δ Tauri | 4 | 15 | 49.27 | − 0.02 | + 0.22 | + 0.03 | 4 | 15 | 59.28 | | | 09.78 | + 0.01 | | | 09.79 |
| D. | ε Tauri | 4 | 21 | 24.98 | − 0.01 | + 0.23 | + 0.03 | 4 | 21 | 34.91 | | | 09.68 | + 0.01 | | | 09.69 |
| D. | ν Eridani | 4 | 30 | 08.18 | − 0.03 | + 0.17 | + 0.03 | 4 | 30 | 18.11 | | | 09.76 | + 0.01 | | | 09.77 |
| D. | τ Tauri | 4 | 34 | 50.90 | − 0.01 | + 0.26 | + 0.03 | 4 | 35 | 00.84 | | | 09.66 | + 0.01 | | | 09.67 |
| R. | β Orionis | 5 | 08 | 35.38 | − 0.03 | + 0.13 | − 0.06 | 5 | 08 | 45.05 | | | 09.63 | + 0.01 | | | 09.64 |
| R. | τ Orionis | 5 | 11 | 35.85 | − 0.03 | + 0.14 | − 0.06 | 5 | 11 | 45.52 | | | 09.62 | + 0.01 | | | 09.63 |
| R. | β Tauri | 5 | 18 | 30.74 | − 0.01 | + 0.25 | − 0.07 | 5 | 18 | 40.49 | | | 09.58 | + 0.01 | | | 09.59 |
| R. | δ Urs. Min. L. C | 6 | 10 | 50.15 | − 0.46 | − 1.97 | + 1.25 | 6 | 10 | 59.84 | | | 10.87 | + 0.02 | | | 10.89 |
| D. | Urs. Min. L. C | 6 | 10 | 52.76 | − 0.46 | − 2.09 | − 0.75 | 6 | 10 | 59.84 | | | 10.38 | + 0.02 | | | 10.40 |
| R. | γ Geminorum | 6 | 30 | 35.21 | − 0.02 | + 0.17 | − 0.06 | 6 | 30 | 44.90 | | | 09.60 | + 0.02 | | | 09.62 |
| R. | ε Geminorum | 6 | 36 | 21.12 | − 0.01 | + 0.21 | − 0.07 | 6 | 36 | 30.88 | | | 09.63 | + 0.02 | | | 09.65 |
| R. | ξ Geminorum | 6 | 38 | 21.71 | − 0.02 | + 0.18 | − 0.06 | 6 | 38 | 31.38 | | | 09.57 | + 0.02 | | | 09.59 |

| | *s.* | *s.* |
|---|---|---|
| From Carr. 3525, | $c = -0.029$ | $a = -0.109$ |
| α Urs. Min., | $c = +0.102$ | $a = -0.041$ |
| δ Urs. Min., | $c = +0.074$ | $a = +0.044$ |
| Mean .... | $c = +0.049$ | $a = -0.035$ |

Mean $\Delta t_0$ (excluding high stars) = + $09^s.665$ at $2^h.21$ clock-time.

$\rho = -$ 0.0042 gaining.

NOTE.—Used mean for November 13 and 19, $c = +0^s.058$.

TABLE 7.—*Time results, Detroit, Mich., December 7, 1878.—H. M. Adams, observer.*

| Tel. | Star. | $t$ | | | A$a$ | B$b$ | C$(c+\Delta i+abr)$ | $\alpha$ | | | $\Delta t$ | | | $r\rho$ | $\Delta t_0$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *s.* | *h.* | *m.* | *s.* |
| R. | α Urs. Min. | 1 | 14 | 33.26 | + 5.08 | + 0.68 | − 3.34 | 1 | 14 | 45.83 | + 0 | 00 | 09.15 | − 0.02 | + 0 | 00 | 09.13 |
| D. | α Urs. Min. | 1 | 14 | 26.32 | + 5.08 | + 0.86 | + 2.00 | 1 | 14 | 45.83 | | | 11.57 | − 0.02 | | | 11.55 |
| D. | ο Piscium | 1 | 38 | 54.23 | − 0.09 | + 0.13 | + 0.04 | 1 | 39 | 01.78 | | | 07.47 | − 0.01 | | | 07.46 |
| D. | β Arietis | 1 | 47 | 51.31 | − 0.07 | + 0.15 | + 0.04 | 1 | 47 | 58.91 | | | 07.48 | − 0.01 | | | 07.47 |
| D. | γ Andromedæ | 1 | 56 | 22.25 | − 0.00 | + 0.20 | + 0.04 | 1 | 56 | 30.27 | | | 07.78 | − 0.01 | | | 07.77 |
| D. | α Arietis | 2 | 00 | 14.99 | − 0.06 | + 0.15 | + 0.04 | 2 | 00 | 22.80 | | | 07.68 | − 0.01 | | | 07.67 |
| D. | $\xi^1$ Ceti | 2 | 06 | 29.14 | − 0.09 | + 0.12 | + 0.04 | 2 | 06 | 36.72 | | | 07.51 | − 0.01 | | | 07.50 |
| D. | γ Trianguli | 2 | 10 | 01.28 | − 0.03 | + 0.17 | + 0.04 | 2 | 10 | 09.13 | | | 07.67 | − 0.01 | | | 07.66 |
| D. | ο Ceti | 2 | 13 | 08.03 | − 0.12 | + 0.10 | + 0.04 | 2 | 13 | 15.64 | | | 07.59 | − 0.01 | | | 07.58 |
| R. | $\xi^2$ Ceti | 2 | 21 | 37.76 | − 0.09 | + 0.05 | − 0.07 | 2 | 21 | 45.20 | | | 07.55 | − 0.01 | | | 07.54 |
| R. | ν Arietis | 2 | 31 | 51.03 | − 0.06 | + 0.10 | − 0.07 | 2 | 31 | 58.54 | | | 07.54 | − 0.01 | | | 07.53 |
| R. | ν Ceti | 2 | 36 | 56.25 | − 0.10 | + 0.11 | − 0.07 | 2 | 37 | 03.58 | | | 07.39 | − 0.01 | | | 07.38 |
| R. | 41 Arietis | 2 | 42 | 46.09 | − 0.05 | + 0.15 | − 0.07 | 2 | 42 | 53.60 | | | 07.48 | − 0.01 | | | 07.47 |
| R. | η Eridani | 2 | 50 | 25.46 | − 0.13 | + 0.08 | − 0.07 | 2 | 50 | 32.76 | | | 07.42 | − 0.01 | | | 07.41 |
| R. | α Ceti | 2 | 55 | 51.66 | − 0.10 | + 0.11 | − 0.07 | 2 | 55 | 59.03 | | | 07.43 | − 0.01 | | | 07.42 |
| R. | δ Arietis | 3 | 04 | 37.06 | − 0.07 | + 0.14 | − 0.07 | 3 | 04 | 44.50 | | | 07.44 | 0.00 | | | 07.44 |
| R. | ζ Arietis | 3 | 07 | 51.07 | − 0.06 | + 0.14 | − 0.07 | 3 | 07 | 58.73 | | | 07.65 | 0.00 | | | 07.65 |
| R. | Carr. 491 | 3 | 27 | 12.07 | + 1.74 | + 0.39 | − 1.19 | 3 | 27 | 21.26 | | | 08.25 | 0.00 | | | 08.25 |
| D. | Carr. 491 | 3 | 27 | 10.22 | + 1.74 | + 1.57 | + 0.71 | 3 | 27 | 21.26 | | | 07.02 | 0.00 | | | 07.02 |
| D. | Gr. 750 | 3 | 59 | 12.23 | + 1.34 | + 0.91 | + 0.56 | 3 | 59 | 22.75 | | | 07.71 | 0.00 | | | 07.71 |
| D. | γ Tauri | 4 | 12 | 48.74 | − 0.08 | + 0.14 | + 0.04 | 4 | 12 | 56.49 | | | 07.65 | 0.00 | | | 07.65 |
| D. | δ Tauri | 4 | 15 | 51.71 | − 0.07 | + 0.14 | + 0.04 | 4 | 15 | 59.50 | | | 07.68 | 0.00 | | | 07.68 |
| D. | ε Tauri | 4 | 21 | 27.40 | − 0.07 | + 0.15 | + 0.04 | 4 | 21 | 35.15 | | | 07.63 | 0.00 | | | 07.63 |
| D. | ν Eridani | 4 | 30 | 10.74 | − 0.12 | + 0.11 | + 0.04 | 4 | 30 | 18.32 | | | 07.55 | 0.00 | | | 07.55 |
| D. | τ Tauri | 4 | 34 | 53.28 | − 0.06 | + 0.17 | + 0.04 | 4 | 35 | 01.10 | | | 07.67 | + 0.01 | | | 07.68 |
| D. | μ Eridani | 4 | 39 | 21.47 | − 0.12 | + 0.12 | + 0.04 | 4 | 39 | 29.08 | | | 07.57 | + 0.01 | | | 07.58 |
| D. | $\pi^4$ Orionis | 4 | 44 | 40.06 | − 0.10 | + 0.14 | + 0.04 | 4 | 44 | 47.68 | | | 07.54 | + 0.01 | | | 07.55 |
| D. | $\pi^5$ Orionis | 4 | 47 | 51.22 | − 0.10 | + 0.14 | + 0.04 | 4 | 47 | 58.90 | | | 07.60 | + 0.01 | | | 07.61 |
| D. | ε Urs. Min., L. C | 4 | 58 | 09.32 | − 0.99 | − 0.59 | − 0.35 | 16 | 58 | 14.79 | | | 07.40 | + 0.01 | | | 07.41 |
| R. | ε Urs. Min., L. C | 4 | 58 | 07.54 | − 0.99 | − 0.25 | + 0.57 | 16 | 58 | 14.79 | | | 07.92 | + 0.01 | | | 07.93 |
| R. | β Orionis | 5 | 08 | 37.85 | − 0.13 | + 0.09 | − 0.07 | 5 | 08 | 45.33 | | | 07.59 | + 0.01 | | | 07.60 |
| R. | τ Orionis | 5 | 11 | 38.45 | − 0.12 | + 0.09 | − 0.07 | 5 | 11 | 45.79 | | | 07.44 | + 0.01 | | | 07.45 |
| R. | β Tauri | 5 | 18 | 33.18 | − 0.04 | + 0.16 | − 0.07 | 5 | 18 | 40.85 | | | 07.62 | + 0.01 | | | 07.63 |
| R. | δ Orionis | 5 | 25 | 44.07 | − 0.11 | + 0.10 | − 0.07 | 5 | 25 | 51.50 | | | 07.51 | + 0.01 | | | 07.52 |
| R. | $\phi^1$ Orionis | 5 | 28 | 05.22 | − 0.09 | + 0.12 | − 0.07 | 5 | 28 | 12.68 | | | 07.50 | + 0.01 | | | 07.51 |
| R. | ε Orionis | 5 | 29 | 58.95 | − 0.11 | + 0.10 | − 0.07 | 5 | 30 | 06.37 | | | 07.50 | + 0.01 | | | 07.51 |
| R. | ν Aurigæ | 5 | 43 | 01.11 | − 0.01 | + 0.28 | − 0.07 | 5 | 43 | 08.71 | | | 07.41 | + 0.01 | | | 07.42 |
| R. | α Orionis | 5 | 48 | 31.78 | − 0.09 | + 0.18 | − 0.07 | 5 | 48 | 39.27 | | | 07.47 | + 0.01 | | | 07.48 |
| R. | δ Urs. Min., L. C | 6 | 10 | 48.18 | − 2.14 | − 1.17 | + 1.31 | 18 | 10 | 55.55 | | | 09.37 | + 0.02 | | | 09.39 |
| D. | δ Urs. Min., L. C | 6 | 10 | 50.48 | − 2.14 | − 1.14 | − 0.79 | 18 | 10 | 55.55 | | | 09.14 | + 0.02 | | | 09.16 |

From α Urs. Min., $c = +0^s.078$ $a = -0^s.268$
Carr. 491. $c = +0^s.022$ $a = -0^s.183$
Gr. 750, $a = -0^s.181$

From ε Urs. Min., $c = +0^s.097$ $a = -0^s.161$
δ Urs. Min., $c = +0^s.069$ $a = -0^s.021$

Mean.................................... $c = +0^s.066$ $a = -0^s.163$

Mean $\Delta t_0$ (excluding high stars) $= +07^s.549$ at $3^h.73$ clock time.
$\rho = -\ 0^s.064$ gaining −.

*Note.*—(Used Mean $c$ for November 13 and 19 and December 7) $= +0^s.062$.

TABLE 8.—*Time results, Detroit, Mich., December 15, 1878.—H. M. Adams, observer.*

| Tel. | Star. | $t$ | A$a$ | B$b$ | $C(c+\Delta i+abr)$ | $\alpha$ | $\Delta t$ | $r\rho$ | $\Delta t_0$ |
|---|---|---|---|---|---|---|---|---|---|
| | | h. m. s. | s. | s. | s. | h. m. s. | h. m. s. | s. | h. m. s. |
| R. | α Urs. Min | 1 14 29.63 | +4.08 | −2.53 | −3.21 | 1 14 39.97 | +0 00 12.00 | +0.11 | +0 00 12.11 |
| D. | α Urs. Min | 1 14 23.94 | +4.08 | −1.43 | +1.87 | 1 14 39.97 | 11.51 | +0.11 | 11.62 |
| D. | ο Piscium | 1 38 54.60 | −0.07 | +0.05 | +0.03 | 1 39 01.72 | 07.11 | +0.09 | 07.20 |
| D. | β Arietis | 1 47 51.85 | −0.05 | +0.06 | +0.03 | 1 47 58.85 | 06.96 | +0.08 | 07.04 |
| D. | γ Andromedæ | 1 56 22.89 | 0.00 | +0.08 | +0.04 | 1 56 30.21 | 07.20 | +0.07 | 07.27 |
| D. | α Arietis | 2 00 15.64 | −0.05 | +0.01 | +0.04 | 2 00 22.76 | 07.12 | +0.06 | 07.18 |
| D. | ξ¹ Ceti | 2 06 29.66 | −0.07 | +0.01 | +0.03 | 2 06 36.69 | 07.06 | +0.06 | 07.12 |
| D. | ο Ceti | 2 13 08.53 | −0.09 | −0.01 | +0.03 | 2 13 15.60 | 07.14 | +0.05 | 07.19 |
| R. | ξ² Ceti | 2 21 38.23 | −0.07 | −0.02 | −0.06 | 2 21 45.17 | 07.09 | +0.04 | 07.13 |
| R. | γ Ceti | 2 36 56.65 | −0.08 | −0.01 | −0.06 | 2 37 03.56 | 07.06 | +0.03 | 07.09 |
| R. | η Eridani | 2 50 25.77 | −0.10 | −0.01 | −0.06 | 2 50 32.74 | 07.14 | +0.01 | 07.15 |
| R. | α Ceti | 2 55 51.96 | −0.08 | 0.00 | −0.06 | 2 55 59.02 | 07.20 | +0.01 | 07.21 |
| R. | δ Arietis | 3 04 38.40 | −0.05 | −0.03 | −1.08 | 3 04 44.51 | 07.27 | 0.00 | 07.27 |
| R. | Carr. 491 | 3 27 15.59 | +1.40 | −1.07 | −1.15 | 3 27 20.66 | 05.89 | −0.03 | 05.86 |
| D. | Carr. 491 | 3 27 14.02 | +1.40 | −0.44 | +0.67 | 3 27 20.66 | 05.01 | −0.03 | 04.98 |
| D. | γ Tauri | 4 12 49.37 | −0.06 | −0.04 | +0.03 | 4 12 56.54 | 07.24 | −0.07 | 07.17 |
| D. | ε Tauri | 4 21 27.97 | −0.05 | −0.01 | +0.03 | 4 21 35.22 | 07.28 | −0.08 | 07.20 |
| D. | δ Orionis | 5 25 44.37 | −0.09 | 0.00 | +0.03 | 5 25 51.60 | 07.29 | −0.15 | 07.14 |
| D. | α Orionis | 5 48 32.15 | −0.08 | −0.03 | +0.03 | 5 48 39.39 | 07.32 | −0.17 | 07.15 |

From α Urs. Min., $c = +0^s.053$ $a = -0^s.276$.
Carr. 491, $c = +0.031$ $a = +0.014$.

Mean.......... $c = +0.042$ $a = -0.131$.

Mean, $\Delta t_0$ (excluding high stars) $= +7^s.165$ at $3^h.02$ clock time.
$\rho = +0.0623$ losing.

*Note.*—(Used weighted $c$ for November 13 and 19, and December 7 and 15) $c = +0^s.059$.

TABLE 9.—*Time results, Rock Island, Ill., September 26, 1878.—C. F. Powell, observer.*

| Cl. | Star. | t | Aa | Bb | C (c+Δi+a b r) | α | Δt | rρ | Δt₀ |
|---|---|---|---|---|---|---|---|---|---|
| | | h. m. s. | s. | s. | s. | h. m. s. | h. m. s. | s. | h. m. s. |
| E. | 1 Draconis, L. C | 15 12 12.27 | + 0.21 | + 0.27 | + 0.06 | 9 19 38.25 | + 6 07 25.46 | + 0.10 | (+ 6 07 25.56) |
| W. | ζ Aquarii | 15 23 54.20 | + 0.03 | + 0.07 | 0.00 | 9 81 19.51 | + 6 07 25.21 | + 0.09 | + 6 07 25.30 |
| W. | ϵ Pegasi | 15 30 50.08 | + 0.02 | + 0.09 | 0.00 | 21 38 15.50 | + 6 07 25.31 | + 0.08 | + 6 07 25.39 |
| W | μ Capricorni | 15 39 17.64 | + 0,03 | + 0.07 | 0.00 | 21 46 42.96 | + 6 07 25.22 | + 0.08 | + 6 07 25.30 |
| W. | 20 Pegasi | 15 47 47.12 | + 0.02 | + 0.12 | 0.00 | 21 55 12.62 | + 6 07 25.36 | + 0.08 | + 6 07 25.44 |
| W. | α Aquarii | 15 52 09.68 | + 0.02 | + 0.09 | 0.00 | 21 59 35.12 | + 6 07 25.33 | + 0.07 | + 6 07 25.40 |
| W | θ Pegasi | 15 56 41.26 | + 0.02 | + 0.09 | 0.00 | 22 04 06.74 | + 6 07 25.37 | + 0.07 | + 6 07 25.44 |
| W. | θ Aquarii | 16 03 02.53 | + 0.03 | + 0.07 | 0.00 | 22 10 27.97 | + 6 07 25.34 | + 0.07 | + 6 07 25.41 |
| E. | γ Aquarii | 16 07 59.99 | + 0.02 | + 0.11 | − 0.03 | 22 15 25.41 | + 6 07 25.32 | + 0.07 | + 6 07 25.39 |
| E | π Aquarii | 16 11 41.45 | + 0.02 | + 0.11 | − 0.03 | 22 19 06.88 | + 6 07 25.33 | + 0.06 | + 6 07 25.39 |
| E. | η Aquarii | 16 21 44.45 | + 0.02 | + 0.10 | − 0.47 | 22 29 09.36 | + 6 07 25.26 | + 0.06 | + 6 07 25.32 |
| E. | ζ Pegasi | 16 28 01.26 | + 0.02 | + 0.11 | − 0.03 | 22 35 26.61 | + 6 07 25.25 | + 0.06 | + 6 07 25.31 |
| E. | λ Pegasi | 16 33 34.88 | + 0.01 | + 0.13 | −17.22 | 22 40 43.27 | + 6 07 25.47 | + 0.05 | + 6 07 25.52 |
| E. | λ Aquarii | 16 38 57.48 | + 0.03 | + 0.09 | − 3.49 | 22 46 19.19 | + 6 07 25.08 | + 0.05 | + 6 07 25.13 |
| E. | Carr. 3525 | 16 47 58.98 | − 0.22 | + 0.71 | − 0.07 | 22 55 25.21 | + 6 07 25.81 | + 0.05 | (+ 6 07 25.97 |
| W. | Carr. 3525 | 16 47 59.67 | − 0.22 | − 0.06 | − 0.21 | 22 55 25.21 | + 6 07 26.03 | + 0.05 | .............. |
| W. | Polaris | 19 07 20.95 | − 1.13 | + 1.63 | − 0.98 | 1 14 58.58 | + 6 07 29.11 | − 0.03 | (+ 6 07 28.75) |
| E. | Polaris | 19 07 30.61 | − 1.13 | + 1.01 | − 0.36 | 1 14 58.58 | + 6 07 28.45 | − 0.03 | .............. |
| E. | α Arietis | 19 52 56.71 | + 0.01 | + 0.09 | − 0.03 | 2 00 22.30 | + 6 07 25.52 | − 0.05 | + 6 07 25.47 |
| E. | ξ¹ Ceti | 19 59 10.81 | + 0.02 | + 0.09 | − 0.03 | 2 06 36.23 | + 6 07 25.34 | − 0.05 | + 6 07 25.29 |
| E. | o Ceti | 20 05 49.65 | + 0.02 | + 0.08 | − 0.03 | 2 13 15.13 | + 6 07 25.41 | − 0.05 | + 6 07 25.36 |
| W. | ξ² Ceti | 20 14 19.16 | + 0.02 | + 0.08 | 0.00 | 2 21 44.60 | + 6 07 25.34 | − 0.06 | + 6 07 25.28 |
| W. | ν Arietis | 20 24 32.29 | + 0.01 | + 0.06 | 0.00 | 2 31 57.87 | + 6 07 25.51 | − 0.07 | + 6 07 25.44 |
| W. | γ Ceti | 20 29 40.02 | + 0.02 | + 0.05 | − 2.72 | 2 37 02.89 | + 6 07 25.52 | − 0.07 | + 6 07 25.45 |
| W. | 41 Arietis | 20 35 27.18 | + 0.01 | + 0.08 | 0.00 | 2 42 52.74 | + 6 07 25.47 | − 0.07 | + 6 07 24.40 |
| W. | η Eridani | 20 43 06.57 | + 0.03 | + 0.06 | 0.00 | 2 50 32.02 | + 6 07 25.36 | − 0.08 | + 6 07 25.28 |
| W. | α Ceti | 20 48 32.64 | + 0.02 | + 0.08 | 0.00 | 2 55 58.21 | + 6 07 25.47 | − 0.08 | + 6 07 25.39 |
| W. | Carr. 491 | 21 19 45.97 | − 0.39 | + 0.62 | − 0.35 | 3 27 10.63 | + 6 07 24.78 | − 0.10 | (+ 6 07 24.40) |
| E. | Carr. 491 | 21 19 45.39 | − 0.39 | + 1.53 | − 0.13 | 3 27 10.63 | + 6 07 24.23 | − 0.10 | .............. |
| E. | η Tauri | 21 32 52.77 | + 0.11 | + 0.11 | − 0.03 | 3 40 18.31 | + 6 07 25.45 | − 0.10 | + 6 07 25.35 |
| E. | 27 Tauri | 21 34 33.26 | + 0.01 | + 0.11 | − 0.03 | 3 41 58.85 | + 6 07 25.50 | − 0.10 | + 6 07 25.40 |
| E. | ζ Persei | 21 39 06.78 | + 0.01 | + 0.13 | − 0.03 | 3 46 32.40 | + 6 07 25.51 | − 0.11 | + 6 07 25.40 |
| E. | Gr. 750 | 21 51 45.74 | − 0.30 | + 1.17 | − 0.10 | 3 59 11.25 | + 6 07 24.74 | − 0.12 | (+ 6 07 24.48) |
| W. | Gr. 750 | 21 51 46.18 | − 0.30 | + 1.18 | − 0.28 | 3 59 11.25 | + 6 07 24.23 | − 0.12 | .............. |

From 1 Draconis, L. C.

| | | |
|---|---|---|
| Carr. 3525, | $c = +0^{s}.005$ Cl. W. | $a = 0^{s}.081$ E. of S. |
| Polaris, | $c = 0^{s}.000$ Cl. W. | $a = 0^{s}.078$ W. of S. |
| Carr. 491, | $c = +0^{s}.011$ Cl. W. | $a = 0^{s}.072$ W. of S. |
| Gr. 750, | $c = -0^{s}.019$ Cl. W. | $a = 0^{s}.111$ E. of S. |
| | | $a = 0^{s}.140$ E. of S. |
| Mean........ | $c = -0^{s}.007$ Cl. W. | Mean......$a = 0^{s}.036$ E. of S. |

Mean $\Delta t_0$ (excluding high stars) $= + 6^{h}\ 07^{m}\ 25^{s}.37$ at $18^{h}.26$ chr. time.
$\rho = +$ $0^{s}.032$. (losing)

TABLE 10.—*Time results, Rock Island, Ill., September 30, 1878. C. F. Powell, observer.*

| Cl. | Star. | $t$ | A $a$ | B $b$ | C $(c+\Delta i+abr)$ | $\alpha$ | $\Delta t$ | $r\rho$ | $\Delta t_0$ |
|---|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *h. m. s.* | *s.* | *h. m. s.* |
| E. | ξ Aquarii | 15 23 54.38 | + 0.31 | + 0.08 | + 0.04 | 21 31 19.47 | + 6 07 24.66 | − 0.11 | + 6 07 24.55 |
| E. | ε Pegasi | 15 30 50.19 | + 0.21 | + 0.10 | + 0.04 | 21 38 15.46 | + 6 07 24.92 | − 0.10 | + 6 07 24.82 |
| E. | μ Capricorni | 15 39 17.63 | + 0.34 | + 0.04 | + 0.04 | 21 46 42.93 | + 6 07 24.88 | − 0.09 | + 6 07 24.79 |
| E. | α Aquarii | 15 52 09.91 | + 0.27 | + 0.02 | + 0.04 | 21 59 35.10 | + 6 07 24.86 | − 0.08 | + 6 07 24.78 |
| E. | θ Pegasi | 15 56 41.54 | + 0.24 | + 0.02 | + 0.04 | 22 04 06.70 | + 6 07 24.86 | − 0.07 | + 6 07 24.79 |
| E. | θ Aquarii | 16 03 02.79 | + 0.31 | + 0.01 | + 0.04 | 22 10 27.95 | + 6 07 24.80 | − 0.07 | + 6 07 24.73 |
| W. | γ Aquarii | 16 08 00.30 | + 0.28 | + 0.07 | − 0.08 | 22 15 25.40 | + 6 07 24.83 | − 0.07 | + 6 07 24.76 |
| W. | π Aquarii | 16 11 41.71 | + 0.26 | + 0.07 | − 0.08 | 22 19 06.86 | + 6 07 24.86 | − 0.06 | + 6 07 24.80 |
| W. | η Aquarii | 16 21 44.23 | + 0.27 | + 0.02 | − 0.08 | 22 29 09.34 | + 6 07 24.88 | − 0.05 | + 6 07 24.83 |
| W. | λ Pegasi | 16 33 23.95 | + 0.14 | + 0.07 | − 5.91 | 22 40 43.24 | + 6 07 24.99 | − 0.04 | + 6 07 24.95 |
| W. | μ Pegasi | 16 36 45.81 | + 0.13 | + 0.10 | − 0.08 | 22 44 10.82 | + 6 07 24.86 | − 0.04 | + 6 07 24.82 |
| W. | λ Aquarii | 16 38 54.12 | + 0.31 | + 0.09 | − 0.08 | 22 46 19.18 | + 6 07 24.75 | − 0.04 | + 6 07 24.71 |
| W. | Carr. 3525 | 16 48 02.32 | − 2.46 | + 1.11 | − 0.46 | 22 55 24.92 | + 6 07 24.41 | − 0.03 | (+ 6 07 24.54) |
| E. | Carr. 3525 | 16 48 01.69 | − 2.46 | + 0.78 | + 0.18 | 22 55 24.92 | + 6 07 24.73 | − 0.03 | |
| E. | 4 Draconis (H), L. C | 17 59 00.35 | + 1.70 | − 0.21 | − 0.09 | 12 06 26.63 | + 6 07 24.88 | + 0.03 | (+ 6 07 25.00) |
| W. | 4 Draconis (H), L. C | 17 58 59.70 | + 1.70 | − 0.09 | + 0.25 | 12 06 26.63 | + 6 07 25.07 | + 0.03 | |
| W. | 12 Ceti | 18 16 28.21 | + 0.29 | + 0.08 | − 0.34 | 0 23 53.11 | + 6 07 24.87 | + 0.05 | + 6 07 24.92 |
| W. | π Andromedæ | 18 23 01.51 | + 0.06 | + 0.14 | − 0.09 | 0 30 26.45 | + 6 07 24.83 | + 0.05 | + 6 07 24.88 |
| W. | ο Cassiopejæ | 18 30 36.06 | − 0.06 | + 0.23 | − 0.10 | 0 38 00.62 | + 6 07 24.49 | + 0.06 | + 6 07 24.55 |
| W. | Polaris | 19 07 45.31 | −12.63 | + 1.95 | − 2.17 | 1 15 00.12 | + 6 07 27.66 | + 0.09 | (+ 6 07 25.72) |
| E. | Polaris | 19 07 45.14 | −12.63 | + 3.18 | + 0.83 | 1 15 00.12 | + 6 07 23.60 | + 0.09 | |
| E. | β Arietis | 19 40 33.50 | + 0.11 | + 0.15 | + 0.05 | 1 47 58.55 | + 6 07 24.74 | + 0.13 | + 6 07 24.87 |
| E. | α Arietis | 19 52 57.41 | + 0.14 | + 0.15 | + 0.05 | 2 00 22.36 | + 6 07 24.61 | + 0.13 | + 6 07 24.74 |
| E. | ξ¹ Ceti | 19 59 11.41 | + 0.22 | + 0.13 | + 0.04 | 2 06 36.28 | + 6 07 24.48 | + 0.14 | + 6 07 24.62 |
| E. | γ Trianguli | 20 02 43.58 | + 0.07 | + 0.19 | + 0.05 | 2 10 08.58 | + 6 07 24.69 | + 0.14 | + 6 07 24.83 |
| E. | ο Ceti | 20 05 50.13 | + 0.31 | + 0.10 | + 0.04 | 2 13 15.19 | + 6 07 24.61 | + 0.14 | + 6 07 24.75 |

| | | *s.* | *s.* |
|---|---|---|---|
| From Carr. 3525, | $c = +0.053$ Cl. E. | | $a = 0.427$ E. of S. |
| 4 Draconis (H), L. C., | $c = +0.053$ Cl. E. | | $a = 0.412$ E. of S. |
| Polaris, | $c = -0.001$ Cl. E. | | $a = 0.367$ E. of S. |
| Mean | $c = +0.035$ Cl. E. | Mean | $a = 0.402$ E. of S. |

Mean $\Delta t_0$ (excluding slow stars) $= + 6^h\ 07^m\ 24^s.774$ at $17^h\ 39$ chr. time.

$\rho = -\ 0^s.053$ gaining.

TABLE 11.—*Time results, Red Wing, Minn., October 24, 1878.—C. F. Powell, observer.*

| Cl. | Star. | $t$ | A $a$ | B $b$ | C($c$ + $i$ + $abr$) | $a$ | $\Delta t$ | $r\rho$ | $\Delta t_0$ |
|---|---|---|---|---|---|---|---|---|---|
|  |  | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *m. s.* | *s.* | *m. s.* |
| W. | 1 Draconis, L. C | 21 08 54.53 | + 1.25 | — 0.85 | — 0.02 | 9 19 42.38 | + 10 47.47 | — 0.16 | (+ 10 47.60) |
| E. | 1 Draconis, L. C | 21 08 53.71 | + 1.25 | — 0.88 | + 0.24 | 9 19 42.38 | + 10 48.06 | — 0.16 | ............ |
| E. | $\epsilon$ Pegasi | 21 27 26.92 | + 0.12 | + 0.29 | — 0.01 | 21 38 15.18 | + 10 47.86 | — 0.11 | + 10 47.75 |
| E. | 20 Pegasi | 21 44 23.95 | + 0.11 | + 0.35 | — 0.01 | 21 55 12.34 | + 10 47.94 | — 0.06 | + 10 47.88 |
| E. | $\alpha$ Aquarii | 21 48 46.54 | + 0.15 | + 0.30 | — 0.01 | 21 59 34.84 | + 10 47.86 | — 0.05 | + 10 47.81 |
| E. | $\theta$ Pegasi | 21 53 18.06 | + 0.13 | + 0.35 | — 0.01 | 22 04 06.48 | + 10 47.95 | — 0.04 | + 10 47.91 |
| E. | $\theta$ Aquarii | 21 59 39.28 | + 0.17 | + 0.28 | — 0.01 | 22 10 27.71 | + 10 47.99 | — 0.02 | + 10 47.97 |
| W. | $\gamma$ Aquarii | 22 04 37.04 | + 0.15 | + 0.27 | — 0.02 | 22 15 25.19 | + 10 47.75 | — 0.01 | + 10 47.74 |
| W. | $\pi$ Aquarii | 22 08 18.45 | + 0.15 | + 0.29 | — 0.02 | 22 19 06.65 | + 10 47.78 | 0.00 | + 10 47.78 |
| W. | $\eta$ Aquarii | 22 18 20.93 | + 0.15 | + 0.30 | — 0.02 | 22 29 09.14 | + 10 47.78 | + 0.03 | + 10 47.81 |
| W. | $\xi$ Pegasi | 22 24 38.15 | + 0.12 | + 0.38 | — 0.02 | 22 35 26.40 | + 10 47.77 | + 0.05 | + 10 47.82 |
| W. | $\lambda$ Pegasi | 22 29 54.66 | + 0.08 | + 0.48 | — 0.02 | 22 40 43.06 | + 10 47.86 | + 0.06 | + 10 47.92 |
| W. | $\mu$ Pegasi | 22 33 23.46 | + 0.08 | + 0.48 | — 1.17 | 22 44 10.64 | + 10 47.79 | + 0.07 | + 10 47.86 |
| W. | $\lambda$ Aquarii | 22 35 30.88 | + 0.17 | + 0.37 | — 0.02 | 22 46 19.02 | + 10 47.62 | + 0.08 | + 10 47.70 |
| W. | Carr. 3525 | 22 44 32.92 | — 1.26 | + 3.12 | + 0.02 | 22 55 22.35 | + 10 47.55 | + 0.11 | (+ 10 47.42) |
| E. | Carr. 3525 | 22 44 33.42 | — 1.26 | + 3.42 | — 0.30 | 22 55 22.35 | + 10 47.07 | + 0.11 | ............ |

From 1 Draconis, L. C., Oct. 24, $c = +0^{s}.660$ Cl. W.
Carr. 3525, Oct. 24, $c = +0.044$ Cl. W.
1 Draconis, L. C., an l 30 Camel., L. C., Oct. 31, $c = -0.020$ Cl. W.
Carr. 3525, Oct. 31, $c = +0.021$ Cl. W.
Polaris, Oct. 31, $c = -0.014$ Cl. W.

*Mean........................ ....... $c = +0.018$ Cl. W.

$a = 0^{s}.166$ E. of S.
$a = 0.267$ E. of S.

$a = 0.216$ E. of S.

Mean $\Delta t_0$ (excluding slow stars) = + 10 *m.* $47^{s}.828$ at $22^{h}.12$ ch. time.

† $\rho$ = + 0.104 losing.

* No known change of collimation between dates.

† The mean daily rate from the 23d to the 27th inclusive is used, which is $+2^{s}.5$.

TABLE 12.—*Time results, Red Wing, Minn., October 31, 1878.—C. F. Powell, observer.*

| Cl. | Star. | $t$ | A$a$ | B$b$ | C$(c+\Delta i+abr)$ | $\alpha$ | $\Delta t$ | $r\rho$ | $t_0$ |
|---|---|---|---|---|---|---|---|---|---|
| | | h. m. s. | s. | s. | s. | h. m. s. | m. s. | s. | m. s. |
| E. | 76 Draconis | 20 41 06.45 | − 1.86 | − 0.19 | −59.75 | 20 51 12.92 | + 11 08.27 | + 0.21 | (+ 11 08.48) |
| E. | ζ Cygni | 20 56 38.64 | + 0.12 | + 0.11 | − 0.01 | 21 07 47.36 | + 11 08.50 | + 0.19 | + 11 08.69 |
| E. | α Equulei | 20 58 37.97 | + 0.27 | + 0.07 | − 0.01 | 9 09 46.84 | + 11 08.54 | + 0.19 | + 11 08.73 |
| E. | 1 Draconis, L. C | 21 08 33.18 | + 2.37 | − 0.12 | − 0.05 | 21 19 43.55 | + 11 08.17 | + 0.17 | (+ 11 08.34) |
| E. | ξ Aquarii | 21 20 10.12 | + 0.34 | + 0.05 | − 0.01 | 21 31 19.10 | + 11 08.60 | + 0.16 | + 11 08.76 |
| E. | ε Pegasi | 21 27 06.16 | + 0.25 | + 0.08 | − 0.01 | 21 38 15.08 | + 11 08.60 | + 0.15 | + 11 08.75 |
| E. | μ Capricorni | 21 35 33.51 | + 0.37 | + 0.06 | − 0.01 | 21 46 42.56 | + 11 08.63 | + 0.14 | + 11 08.77 |
| E. | 20 Pegasi | 21 44 03.25 | + 0.23 | + 0.09 | − 0.01 | 21 55 12.24 | + 11 08.68 | + 0.13 | + 11 08.81 |
| E. | α Aquarii | 21 48 25.75 | + 0.30 | + 0.07 | − 0.01 | 21 59 34.76 | + 11 08.65 | + 0.12 | + 11 08.77 |
| W. | θ Pegasi | 21 52 57.57 | + 0.26 | + 0.12 | − 0.02 | 22 04 06.40 | + 11 08.47 | + 0.12 | + 11 08.59 |
| W. | θ Aquarii | 21 59 18.76 | + 0.34 | + 0.09 | − 0.02 | 22 10 27.63 | + 11 08.46 | + 0.11 | + 11 08.57 |
| W. | 30 Camelop., L. C | 22 04 58.00 | + 2.78 | − 0.16 | + 0.48 | 10 16 09.96 | + 11 08.86 | + 0.10 | (+ 11 08.96) |
| W. | η Aquarii | 22 18 02.65 | + 0.30 | + 0.09 | − 2.50 | 22 29 09.06 | + 11 08.52 | + 0.09 | + 11 08.61 |
| W. | ζ Pegasi | 22 24 18.94 | + 0.24 | + 0.13 | − 1.50 | 22 35 26.32 | + 11 08.51 | + 0.08 | + 11 08.59 |
| W. | λ Pegasi | 22 29 34.00 | + 0.17 | + 0.20 | − 0.02 | 22 40 42.98 | + 11 08.63 | + 0.07 | + 11 08.70 |
| W. | μ Pegasi | 22 33 01.71 | + 0.16 | + 0.23 | − 0.02 | 22 44 10.56 | + 11 08.48 | + 0.07 | + 11 08.55 |
| W. | λ Aquarii | 22 35 10.13 | + 0.34 | + 0.13 | − 0.01 | 22 46 18.95 | + 11 08.37 | + 0.06 | + 11 08.43 |
| W. | Carr. 3525 | 22 44 14.92 | − 2.40 | + 0.11 | + 0.02 | 22 55 21.30 | + 11 08.65 | + 0.05 | .............. |
| E. | Carr. 3525 | 22 44 14.80 | − 2.40 | + 0.62 | − 0.30 | 22 55 21.30 | + 11 08.68 | + 0.05 | (+ 11 08.71) |
| E. | Polaris | 1 04 07.37 | −12.50 | − 0.09 | − 1.41 | 1 15 01.99 | + 11 08.62 | − 0.13 | .............. |
| W. | Polaris | 1 04 08.36 | −12.50 | + 0.09 | + 0.13 | 1 15 01.99 | + 11 05.91 | − 0.13 | (+ 11 07.13) |
| W. | α Trianguli | 1 35 03.69 | + 0.13 | + 0.08 | − 0.02 | 1 46 12.70 | + 11 08.82 | − 0.17 | + 11 08.65 |
| W. | β Arietis | 1 36 49.98 | + 0.18 | + 0.07 | − 0.02 | 1 47 58.89 | + 11 08.68 | − 0.17 | + 11 08.51 |
| W. | α Arietis | 1 49 13.60 | + 0.17 | + 0.16 | − 0.02 | 2 00 22.74 | + 11 08.83 | − 0.19 | + 11 08.64 |
| E. | 41 Arietis | 2 31 36.56 | + 0.14 | + 0.28 | + 7.61 | 2 42 53.37 | + 11 08.78 | − 0.24 | + 11 08.54 |
| E. | ζ Arietis | 2 56 49.07 | + 0.18 | + 0.28 | − 0.01 | 3 07 58.42 | + 11 08.90 | − 0.27 | + 11 08.63 |
| E. | Carr. 491 | 3 16 12.19 | − 4.27 | + 1.73 | − 0.51 | 3 27 19.12 | + 11 09.98 | − 0.30 | (+ 11 09.68) |
| E. | 17 Tauri | 3 26 33.35 | + 0.16 | + 0.27 | + 0.22 | 3 37 43.03 | + 11 09.03 | − 0.31 | + 11 08.72 |
| E. | ζ Persei | 3 35 23.60 | + 0.11 | + 0.29 | − 0.01 | 3 46 33.27 | + 11 09.28 | − 0.32 | + 11 08.96 |

From 76 Draconis and 1 Draconis, L. C. Oct. 31, $a = 0^{s}.402$ E. of S.
1 Draconis, L. C. Oct. 24, $c = +0^{s}.060$ Cl. W.
Carr. 3525, Oct. 24, $c = +0^{s}.044$ Cl. W.
1 Draconis, L. C., and 30 Camel., L. C. Oct. 31, $c = -0^{s}.020$ Cl. W.
30 Camel., L. C., and Carr. 3525, Oct. 31, $a = 0^{s}.443$ E. of S.
Carr. 3525, Oct. 31, $c = +0^{s}.021$ Cl. W.
Polaris, Oct. 31, $c = -0^{s}.014$ Cl. W. $a = 0^{s}.478$ E. of S.
Carr. 491, Oct. 31, $a = 0^{s}.350$ E. of S.

* Mean......$c = +0^{s}.018$ C. L., W. $a = 0^{s}.418$ E. of S.

Mean $\Delta t_0$ (excluding slow stars) $= +11^{m}\ 08^{s}.665$ at $23^{h}.41$ ch. time.

$\rho = +\ 0^{s}.077$ losing.

* No known change of collimation between dates.

TABLE 13.—*Time results, Louisiana, Mo., November 13, 1878.—C. F. Powell, observer.*

| Cl. | Star. | $t$ | $Aa$ | $Bb$ | $C(c+\Delta i+abr)$ | $\alpha$ | $\Delta t$ | $r\rho$ | $\Delta t_0$ |
|---|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *s.* | *s.* | *s.* |
| E. | 30 Camel (L. C) | 22 15 50.46 | + 0.35 | − 0.40 | + 1.67 | 10 16 12.40 | + 20.32 | − 0.04 | + 20.28 |
| E. | η Aquarii | 22 28 48.11 | + 0.03 | + 0.08 | − 0.05 | 22 29 08.91 | 20.73 | − 0.04 | 20.69 |
| E. | ζ Pegasi | 22 35 05.46 | + 0.02 | + 0.10 | − 0.06 | 22 35 26.17 | 20.65 | − 0.04 | 20.61 |
| E. | λ Pegasi | 22 40 21.99 | + 0.02 | + 0.12 | − 0.06 | 23 40 42.82 | 20.75 | − 0.03 | 20.72 |
| E. | μ Pegasi | 22 43 49.51 | + 0.01 | + 0.13 | − 0.06 | 22 44 10.40 | 20.81 | − 0.03 | 20.78 |
| W. | Carr. 3525 | 22 54 58.08 | − 0.32 | + 0.26 | − 0.13 | 22 55 19.15 | 21.26 | − 0.03 | 21.23 |
| W. | γ Piscium | 23 10 33.56 | + 0.03 | + 0.06 | + 0.02 | 23 10 54.39 | 20.72 | − 0.03 | 20.69 |
| W. | τ Pegasi | 23 14 18.79 | + 0.02 | + 0.08 | + 0.03 | 23 14 39.73 | 20.81 | − 0.03 | 20.78 |
| W. | υ Pegasi | 23 19 00.29 | + 0.02 | + 0.09 | + 0.02 | 23 19 21.26 | 20.84 | − 0.03 | 20.81 |
| W. | θ Piscium | 23 21 29.90 | + 0.03 | + 0.07 | + 0.02 | 23 21 50.68 | 20.66 | − 0.03 | 20.63 |
| W. | ι Piscium | 23 33 23.73 | + 0.03 | + 0.08 | − 0.01 | 23 33 44.62 | 20.79 | − 0.02 | 20.77 |
| W. | ψ Pegasi | 23 46 00.22 | + 0.02 | + 0.10 | + 0.02 | 23 46 20.97 | 20.61 | − 0.02 | 20.59 |
| W. | ω Piscium | 23 52 46.07 | + 0.03 | + 0.09 | + 0.02 | 23 53 06.96 | 20.75 | − 0.02 | 20.73 |
| W. | α Andromedæ | 0 01 48.18 | + 0.01 | + 0.12 | + 0.04 | 0 02 09.12 | 20.77 | − 0.02 | 20.75 |
| E. | γ Pegasi | 0 06 40.42 | + 0.02 | + 0.13 | − 0.06 | 0 07 01.45 | 20.94 | − 0.01 | 20.93 |
| E. | ι Ceti | 0 12 56.11 | + 0.04 | + 0.09 | − 0.06 | 0 13 17.01 | 20.83 | − 0.01 | 20.82 |
| E. | 12 Ceti | 0 23 32.25 | + 0.04 | + 0.11 | − 0.06 | 0 23 53.08 | 20.74 | − 0.01 | 20.73 |
| E. | β Ceti | 0 37 11.39 | + 0.05 | + 0.09 | − 0.06 | 0 37 32.31 | 20.84 | − 0.01 | 20.83 |
| E. | ζ Andromedæ | 0 40 35.88 | + 0.02 | + 0.18 | − 0.06 | 0 40 56.86 | 20.84 | 0.00 | 20.84 |
| E. | α Urs. Min | 1 14 40.38 | − 1.64 | + 1.60 | − 3.42 | 1 14 58.51 | 21.59 | 0.00 | 21.59 |
| W. | α Urs. Min | 1 14 35.10 | − 1.64 | + 2.02 | + 2.08 | 1 14 58.51 | 20.95 | 0.00 | 20.95 |
| W. | 5 Urs. Min. (L. C.) | 2 27 22.67 | + 0.19 | + 0.06 | + 0.06 | 14 27 43.84 | + 20.86 | + 0.02 | + 20.88 |
| W. | γ² Ceti | 2 36 42.61 | + 0.03 | + 0.03 | + 0.02 | 2 37 03.51 | 20.82 | + 0.02 | 20.84 |
| W. | 47 Cephei | 2 49 49.97 | − 0.17 | − 0.02 | − 0.07 | 2 50 10.63 | 20.92 | + 0.02 | 20.94 |
| W. | δ Arietis | 3 04 23.54 | + 0.02 | + 0.08 | + 0.02 | 3 04 44.36 | 20.70 | + 0.03 | 20.73 |
| W. | ζ Arietis | 3 07 37.79 | + 0.02 | + 0.09 | + 0.02 | 3 07 58.58 | 20.66 | + 0.03 | 20.69 |
| W. | o Tauri | 3 17 73.37 | + 0.03 | + 0.09 | −14.40 | 3 18 19.82 | 20.73 | + 0.03 | 20.76 |
| W. | ξ Tauri | 3 20 17.64 | + 0.03 | + 0.10 | + 0.02 | 3 20 38.42 | 20.63 | + 0.03 | 20.66 |
| W. | Carr. 491 | 3 26 50.75 | − 0.56 | + 0.40 | + 0.74 | 3 27 20.75 | 20.42 | + 0.03 | 20.45 |
| E. | Carr. 491 | 3 26 61.64 | − 0.56 | + 0.52 | − 1.22 | 3 27 20.75 | 20.37 | + 0.03 | 20.40 |
| E. | Gr., 750 | 3 59 02.76 | − 0.43 | − 0.02 | − 0.96 | 3 59 21.37 | 20.02 | + 0.04 | 20.06 |
| W. | Gr., 750 | 3 59 00.69 | − 0.43 | + 0.36 | + 0.58 | 3 59 21.37 | 20.17 | + 0.04 | 20.21 |
| E. | δ¹ Tauri | 4 15 38.29 | + 0.02 | + 0.16 | − 0.06 | 4 15 59.17 | 20.76 | + 0.04 | 20.80 |
| E. | ε Tauri | 4 21 13.97 | + 0.02 | + 0.15 | − 0.06 | 4 21 34.81 | 20.73 | + 0.04 | 20.77 |
| E. | ν Eridani | 4 29 57.15 | + 0.03 | + 0.09 | − 0.06 | 4 30 18.00 | 20.79 | + 0.05 | 20.84 |
| E. | τ Tauri | 4 34 39.95 | + 0.02 | + 0.12 | − 0.06 | 4 35 10.71 | 20.68 | + 0.05 | 20.73 |
| E. | μ Eridani | 4 39 08.03 | + 0.03 | + 0.07 | − 0.05 | 4 39 28.74 | + 20.66 | + 0.05 | 20.71 |

From Polaris, $c = +0^s.057$, Cl. W.
Carr. 491, $c = +0^s.066$, Cl. W. $a = 0^s.0538$, E. of S.
Gr. 750, $c = +0^s.070$, Cl. W.

Mean.... $c = +0^s.164$, Cl. W.

Mean $\Delta t_0$ (excluding high stars) $= +20^s.750$ at $1^h.13$ ch. time.
$\rho = 0^s.014$ gaining.

TABLE 14.—*Time results, Louisiana, Mo., November 19, 1878.—C. F. Powell, observer.*

| Cl. | Star. | $t$ | | | $Aa$ | $Bb$ | $C(c+\Delta i+abr)$. | $a$ | | | $\Delta t$ | $rp$ | $\Delta t_0$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* |
| E. | 30 Camel. (L. C.) | 22 | 15 | 51.61 | + 0.04 | + 0.34 | − 0.84 | 10 | 16 | 13.45 | + 22.30 | + 0.02 | + 22.32 |
| E. | η Aquarii | 22 | 28 | 46.04 | 0.00 | + 0.10 | + 0.04 | 22 | 29 | 08.84 | 22.66 | + 0.02 | 22.68 |
| E. | ζ Pegasi | 22 | 35 | 03.33 | 0.00 | + 0.12 | + 0.04 | 22 | 35 | 26.10 | 22.61 | + 0.01 | 22.62 |
| E. | λ Pegasi | 22 | 40 | 19.89 | 0.00 | + 0.15 | + 0.04 | 22 | 40 | 42.74 | 22.66 | + 0.01 | 22.67 |
| E. | μ Pegasi | 22 | 43 | 47.47 | 0.00 | + 0.16 | + 0.04 | 22 | 44 | 10.32 | 22.65 | + 0.01 | 22.66 |
| W. | Carr. 3525 | 22 | 54 | 56.24 | − 0.03 | + 0.74 | − 0.67 | 22 | 55 | 18.10 | 21.82 | + 0.01 | 21.83 |
| W. | γ Piscium | 23 | 10 | 31.73 | 0.00 | + 0.05 | − 0.07 | 23 | 10 | 54.33 | 22.62 | + 0.01 | 22.63 |
| W. | τ Pegasi | 23 | 14 | 17.01 | 0.00 | + 0.06 | − 0.07 | 23 | 14 | 39.66 | 22.66 | + 0.01 | 22.67 |
| W. | υ Pegasi | 23 | 18 | 58.62 | 0.00 | + 0.06 | − 0.07 | 23 | 19 | 21.19 | 22.58 | + 0.01 | 22.59 |
| W. | ο Piscium | 23 | 21 | 28.06 | 0.00 | + 0.05 | − 0.07 | 23 | 21 | 50.62 | 22.58 | + 0.01 | 22.59 |
| W. | ι Piscium | 23 | 33 | 21.95 | 0.00 | + 0.05 | − 0.07 | 23 | 33 | 44.56 | 22.63 | + 0.01 | 22.64 |
| W. | ψ Pegasi | 23 | 45 | 58.36 | 0.00 | + 0.06 | − 0.07 | 23 | 46 | 20.92 | 22.57 | + 0.01 | 22.58 |
| W. | ω Piscium | 23 | 52 | 44.35 | 0.00 | + 0.06 | − 0.07 | 23 | 53 | 06.91 | 22.57 | + 0.01 | 22.58 |
| W. | α Andromedæ | 0 | 01 | 46.31 | 0.00 | + 0.08 | − 0.08 | 0 | 02 | 09.06 | 22.75 | + 0.01 | 22.76 |
| E. | γ Pegasi | 0 | 06 | 47.38 | 0.00 | + 0.10 | − 8.82 | 0 | 07 | 01.40 | 22.74 | + 0.01 | 22.75 |
| E. | ι Ceti | 0 | 12 | 54.18 | 0.00 | + 0.07 | + 0.04 | 0 | 13 | 16.96 | 22.67 | + 0.01 | 22.68 |
| E. | 12 Ceti | 0 | 23 | 30.30 | 0.00 | + 0.07 | + 0.04 | 0 | 23 | 53.04 | 22.63 | 0.00 | 22.63 |
| E. | β Ceti | 0 | 37 | 09.33 | 0.00 | + 0.05 | + 0.04 | 0 | 37 | 32.26 | 22.84 | 0.00 | 22.84 |
| E. | ζ Andromedæ | 0 | 40 | 34.00 | 0.00 | + 0.09 | 0.04 | 0 | 40 | 56.82 | 22.69 | 0.00 | 22.69 |
| E. | α Urs. Min | 1 | 14 | 33.70 | − 0.18 | + 1.24 | 0.49 | 1 | 14 | 55.68 | 21.41 | 0.00 | 21.41 |
| W. | α Urs. Min | 1 | 14 | 34.48 | − 0.18 | + 2.84 | − 1.83 | 1 | 14 | 55.68 | 20.37 | 0.00 | 20.37 |
| W. | 4 Urs. Min. (L. C.) | 2 | 08 | 53.05 | + 0.02 | − 0.14 | + 0.51 | 14 | 09 | 16.40 | 22.96 | − 0.01 | 22.95 |
| W. | $\xi^2$ Ceti | 2 | 21 | 22.59 | 0.00 | + 0.04 | − 0.07 | 2 | 21 | 45.18 | 22.62 | − 0.01 | 22.61 |
| W. | ν Arietis | 2 | 31 | 35.73 | 0.00 | + 0.06 | − 0.05 | 2 | 31 | 58.50 | 22.76 | − 0.01 | 22.75 |
| W. | δ Ceti | 2 | 32 | 64.53 | 0.00 | + 0.05 | − 8.75 | 2 | 33 | 18.50 | 22.67 | − 0.01 | 22.66 |
| W. | γ Ceti | 2 | 36 | 40.96 | 0.00 | + 0.06 | − 0.07 | 2 | 37 | 03.55 | 22.60 | − 0.01 | 22.59 |
| W. | μ Ceti | 2 | 38 | 03.19 | 0.00 | + 0.06 | − 0.07 | 2 | 38 | 25.74 | 22.56 | − 0.01 | 22.55 |
| E. | 41 Arietis | 2 | 42 | 44.09 | 0.00 | + 0.09 | −13.50 | 2 | 42 | 53.54 | 22.86 | − 0.01 | 22.85 |
| E. | 47 Cephei | 2 | 51 | 09.59 | − 0.02 | + 0.36 | −82.09 | 2 | 50 | 10.66 | 22.82 | − 0.01 | 22.81 |
| E. | δ Arietis | 3 | 04 | 21.86 | 0.00 | + 0.11 | + 0.04 | 3 | 04 | 44.41 | 22.40 | − 0.01 | 22.39 |
| E. | τ Tauri | 4 | 34 | 38.05 | 0.00 | + 0.04 | + 0.04 | 4 | 35 | 00.83 | 22.70 | − 0.02 | 22.68 |
| E. | μ Eridani | 4 | 39 | 06.05 | 0.00 | + 0.02 | + 0.04 | 4 | 39 | 28.84 | 22.73 | − 0.02 | 22.71 |
| E. | $\pi^4$ Orionis | 4 | 44 | 24.73 | 0.00 | + 0.02 | + 0.04 | 4 | 44 | 47.43 | 22.64 | − 0.02 | 22.62 |
| E. | $\pi^5$ Orionis | 4 | 47 | 35.91 | 0.00 | + 0.02 | + 0.04 | 4 | 47 | 58.65 | 22.68 | − 0.02 | 22.66 |
| E. | ε Urs. Min. (L. C.) | 4 | 57 | 53.40 | + 0.03 | + 0.04 | − 0.08 | 16 | 58 | 15.72 | 22.33 | − 0.02 | 22.31 |
| W. | ε Urs. Min. (L. C.) | 4 | 57 | 53.18 | + 0.03 | − 0.12 | + 0.32 | 16 | 58 | 15.72 | + 22.31 | − 0.02 | 22.29 |

From α Urs. Min., $c = +0^{s}.028$ Cl. E. $a = +0^{s}.080$
ε Urs. Min., $c = +0^{s}.026$ Cl. E. $a = -0^{s}.058$
30 Camel. and Carr. 3525 $a = +0^{s}.041$
4 Urs. Min. and 47 Cephei $a = -0^{s}.024$

Mean, $c = +0^{s}.027$ Cl. E. $a = +0.^{s}0055$

Mean $\Delta t_0$ (excluding high stars) $= +22^{s}.655$ at $1^{h}.07$ ch. time.
$\rho = +\ 0^{s}.006$. losing.

TABLE 15.—*Time results, Detroit, Mich., December 7, 1878.—C. F. Powell, observer.*

| Cl. | Star. | $t$ | | | A $a$ | B $b$ | C $(c+\Delta i+a b r)$ | $\alpha$ | | | $\Delta t$ | | | $r\rho$ | $\Delta t_0$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | h. | m. | s. | s. | s. | s. | h. | m. | s. | h. | m. | s. | s. | h. | m. | s. |
| E. | Polaris | 1 | 14 | 17.27 | +10.54 | + 0.45 | + 1.25 | 1 | 14 | 45.84 | + 0 | 00 | 16.33 | + 0.36 | + 0 | 00 | 16.69 |
| W. | Polaris | 1 | 14 | 17.43 | +10.54 | + 2.17 | − 2.54 | 1 | 14 | 45.84 | | | 18.24 | + 0.36 | | | 18.60 |
| W. | ο Piscium | 1 | 38 | 44.43 | − 0.20 | + 0.09 | − 0.08 | 1 | 39 | 01.78 | | | 17.54 | + 0.30 | | | 17.84 |
| W. | β Arietis | 1 | 47 | 41.41 | − 0.14 | + 0.11 | − 0.09 | 1 | 47 | 58.91 | | | 17.62 | + 0.28 | | | 17.90 |
| W. | α Arietis | 2 | 00 | 05.24 | − 0.12 | + 0.12 | − 0.09 | 2 | 00 | 22.80 | | | 17.65 | + 0.25 | | | 17.90 |
| W. | $\xi^1$ Ceti | 2 | 06 | 19.44 | − 0.19 | + 0.10 | − 0.08 | 2 | 06 | 36.72 | | | 17.45 | + 0.23 | | | 17.68 |
| W. | ο Ceti | 2 | 12 | 58.28 | − 0.24 | + 0.09 | − 0.08 | 2 | 13 | 15.63 | | | 17.58 | + 0.22 | | | 17.80 |
| W. | $\xi^2$ Ceti | 2 | 21 | 27.89 | − 0.19 | + 0.11 | − 0.08 | 2 | 21 | 45.20 | | | 17.47 | + 0.20 | | | 17.67 |
| E. | ν Arietis | 2 | 31 | 40.68 | − 0.13 | + 0.18 | + 0.06 | 2 | 31 | 58.53 | | | 17.74 | + 0.17 | | | 17.91 |
| E. | γ Ceti | 2 | 36 | 46.00 | − 0.21 | + 0.14 | + 0.05 | 2 | 37 | 03.58 | | | 17.60 | + 0.16 | | | 17.76 |
| E. | 41 Arietis | 2 | 42 | 35.77 | − 0.10 | + 0.20 | + 0.06 | 2 | 42 | 53.60 | | | 17.67 | + 0.15 | | | 17.82 |
| E. | η Eridani | 2 | 50 | 15.14 | − 0.27 | + 0.12 | + 0.05 | 2 | 50 | 32.76 | | | 17.72 | + 0.13 | | | 17.85 |
| E. | α Ceti | 2 | 55 | 57.28 | − 0.21 | + 0.14 | −15.74 | 2 | 55 | 59.03 | | | 17.56 | + 0.12 | | | 17.68 |
| E. | δ Arietis | 3 | 04 | 26.71 | − 0.14 | + 0.18 | + 0.06 | 3 | 04 | 44.49 | | | 17.68 | + 0.10 | | | 17.78 |
| E. | ζ Arietis | 3 | 07 | 40.86 | − 0.13 | + 0.18 | + 0.06 | 3 | 07 | 58.73 | | | 17.76 | + 0.09 | | | 17.85 |
| E | Carr. 491 | 3 | 26 | 57.27 | + 3.60 | + 0.48 | + 0.45 | 3 | 27 | 21.28 | | | 19.48 | + 0.04 | | | 19.52 |
| W. | Carr. 491 | 3 | 26 | 58.95 | + 3.60 | + 0.38 | − 0.91 | 3 | 27 | 21.28 | | | 19.26 | + 0.04 | | | 19.30 |
| W. | G. 750 | 3 | 59 | 02.36 | + 2.67 | + 0.53 | − 0.72 | 3 | 59 | 22,46 | | | 17.62 | − 0.03 | | | 17.59 |
| W. | γ Tauri | 4 | 12 | 38.75 | − 0.16 | + 0.02 | − 0.09 | 4 | 12 | 56.49 | | | 17.97 | − 0.06 | | | 17.91 |
| W. | $\delta^1$ Tauri | 4 | 15 | 41.84 | − 0.15 | + 0.03 | − 0.09 | 4 | 15 | 59.50 | | | 17.87 | − 0.07 | | | 17.80 |
| W. | ε Tauri | 4 | 21 | 17.42 | − 0.14 | + 0.03 | − 0.09 | 4 | 21 | 35.15 | | | 17.93 | — 0.08 | | | 17.85 |
| W. | ι Eridani | 4 | 30 | 00.71 | − 0.24 | + 0.05 | − 0.08 | 4 | 30 | 18.33 | | | 17.89 | − 0.10 | | | 17.79 |
| W. | τ Tauri | 4 | 34 | 43.23 | − 0.12 | + 0.08 | − 0.09 | 4 | 35 | 01.12 | | | 18.02 | − 0.11 | | | 17.91 |
| W. | μ Eridani | 4 | 39 | 11.50 | − 0.24 | + 0.07 | − 0.08 | 4 | 39 | 29.09 | | | 17.84 | − 0.12 | | | 17.72 |
| W. | $\pi^4$ Orionis | 4 | 44 | 30.04 | − 0.20 | + 0.08 | − 0.08 | 4 | 44 | 47.68 | | | 17.84 | − 0.13 | | | 17.71 |
| W. | $\pi^5$ Orionis | 4 | 47 | 41.27 | − 0.22 | + 0.08 | − 0.08 | 4 | 47 | 58.91 | | | 17.86 | − 0.14 | | | 17.72 |
| E. | ε Urs. Min. L. C | 4 | 57 | 58.97 | − 2.06 | − 0.26 | − 0.21 | 16 | 58 | 14.80 | | | 18.36 | − 0.16 | | | 18.20 |
| W. | ε Urs. Min. L. C | 4 | 57 | 58.35 | − 2.06 | − 0.41 | + 0.44 | 16 | 58 | 14.80 | | | 18.48 | − 0.16 | | | 18.32 |
| E. | β Orionis | 5 | 08 | 27.57 | − 0.26 | + 0.05 | + 0.05 | 5 | 08 | 45.33 | | | 17.92 | − 0.19 | | | 17.73 |
| E. | τ Orionis | 5 | 11 | 28.00 | − 0.26 | + 0.05 | + 0.05 | 5 | 11 | 45.80 | | | 17.96 | − 0.20 | | | 17.76 |
| E. | β Tauri | 5 | 18 | 22.87 | − 0.09 | + 0.08 | + 0.06 | 5 | 18 | 40.85 | | | 17.93 | − 0.20 | | | 17.73 |
| E. | δ Orionis | 5 | 25 | 33.50 | − 0.23 | + 0.07 | + 0.05 | 5 | 25 | 51.50 | | | 18.11 | − 0.23 | | | 17.88 |
| E. | $\phi^1$ Orionis | 5 | 27 | 54.70 | − 0.19 | + 0.09 | + 0.05 | 5 | 28 | 12.68 | | | 18.03 | − 0.24 | | | 17.79 |
| E. | ε Orionis | 5 | 29 | 48.45 | − 0.22 | + 0.08 | + 0.05 | 5 | 30 | 06.37 | | | 18.02 | − 0.24 | | | 17.78 |
| E. | θ Aurigæ | 5 | 51 | 12.22 | − 0.04 | + 0.15 | + 0.07 | 5 | 51 | 30.69 | | | 18.29 | − 0.29 | | | 18.00 |
| E. | δ Urs. Min. L. C | 6 | 10 | 42.44 | − 4.44 | − 0.11 | − 0.49 | 18 | 10 | 55.55 | | | 18.15 | − 0.34 | | | 17.81 |
| W. | δ Urs. Min. L. C | 6 | 10 | 41.17 | − 4.44 | − 0.52 | + 1.00 | 18 | 10 | 55.55 | + 0 | 00 | 18.34 | − 0.34 | | | 18.00 |

From Polaris, $c = +0^s.022$ Cl. E. $a = -0^s.332$ W. of S.
Carr. 491, $c = +0^s.052$ Cl. E. $a = -0^s.488$ W. of S.
ε Urs. Min., $c = +0^s.052$ Cl. E. $a = -0^s.237$ W. of S.
δ Urs. Min., $c = +0^s.050$ Cl. E. $a = -0^s.336$ W. of S.
Gr. 750. $a = -0^s.298$ W. of S.

Mean ....$c = +0^s.044$ Cl. E. $a = -0^s.338$ W. of S.

Mean $\Delta t_0$ (excluding high stars) $= +\ 0^h\ 0^m\ 17^s.804$ at $3^h.78$ ch. time.
$\rho = +\ 0^s.139$ losing.

TABLE 16.—*Time results, Detroit, Mich., December 15, 1878.—C. F. Powell, observer.*

| Cl. | Star. | *t* | A *a* | B *b* | C (*c* + Δ*i* + *abr*) | *a* | Δ*t* | *r* ρ | Δ*t*₀ |
|---|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *h. m. s.* | *s.* | *h. m. s.* |
| E. | Polaris | 1 14 02.98 | +3.15 | +2.77 | − 4.53 | 1 14 39.96 | +0 00 35.59 | +0.39 | +0 00 35.98 |
| W. | Polaris | 1 13 52.98 | +3.15 | +0.51 | + 3.23 | 1 14 39.96 | 40.09 | +0.39 | 40.48 |
| W. | o Piscium | 1 38 24.99 | −0.06 | +0.06 | + 0.05 | 1 39 01.72 | 36.68 | +0.30 | 36.98 |
| W. | β Arietis | 1 47 22.05 | −0.04 | +0.07 | + 0.05 | 1 47 58.85 | 36.72 | +0.27 | 36.99 |
| W. | α Arietis | 1 59 45.90 | −0.04 | +0.07 | + 0.05 | 2 00 22.76 | 36.78 | +0.22 | 37.00 |
| W. | ξ¹ Ceti | 2 05 59.96 | −0.06 | +0.06 | + 0.05 | 2 06 36.69 | 36.68 | +0.20 | 36.88 |
| W. | ν Trianguli | 2 09 33.22 | −0.02 | +0.08 | − 1.19 | 2 10 09.08 | 36.99 | +0.18 | 37.17 |
| W. | o Ceti | 2 12 38.84 | −0.07 | +0.05 | + 0.05 | 2 13 15.60 | 36.73 | +0.17 | 36.90 |
| W. | ξ² Ceti | 2 21 08.84 | −0.06 | +0.06 | + 0.05 | 2 21 45.17 | 36.78 | +0.14 | 36.92 |
| E. | ν Arietis | 2 31 21.61 | −0.04 | +0.13 | − 0.09 | 2 31 58.52 | 36.91 | +0.10 | 37.01 |
| E. | ν Ceti | 2 36 26.66 | −0.06 | +0.09 | − 0.08 | 2 37 03.56 | 36.95 | +0.08 | 37.03 |
| E. | 41 Arietis | 2 42 16.58 | −0.03 | +0.11 | − 0.09 | 2 42 53.59 | 37.02 | +0.06 | 37.08 |
| E. | η Eridani | 2 49 55.80 | −0.08 | +0.05 | − 0.08 | 2 50 32.74 | 37.05 | +0.03 | 37.08 |
| E. | α Ceti | 2 55 22.07 | −0.06 | +0.05 | − 0.08 | 2 55 59.02 | 37.04 | +0.02 | 37.06 |
| E. | δ Arietis | 3 04 07.47 | −0.04 | +0.04 | − 0.08 | 3 04 44.51 | 37.12 | −0.02 | 37.10 |
| E. | ξ Arietis | 3 07 21.92 | −0.04 | +0.03 | − 0.09 | 3 07 58.74 | 36.92 | −0.03 | 36.89 |
| E. | Carr. 491 | 3 26 44.12 | +1.08 | −0.73 | − 1.61 | 3 27 20.67 | 37.81 | −0.10 | 37.71 |
| W. | Carr. 491 | 3 26 44.47 | +1.08 | −0.64 | + 1.15 | 3 27 20.67 | 34.61 | −0.10 | 34.51 |
| E. | γ Tauri | 4 12 32.62 | −0.05 | +0.05 | −13.30 | 4 12 56.54 | 37.22 | −0.27 | 36.95 |
| E. | δ Tauri | 4 15 22.32 | −0.04 | +0.05 | − 0.08 | 4 15 59.55 | 37.30 | −0.29 | 37.01 |
| E. | δ Orionis | 5 25 19.38 | −0.07 | +0.08 | − 5.39 | 5 25 51.60 | 37.60 | −0.54 | 37.06 |
| E. | α Orionis | 5 48 01.78 | −0.06 | +0.11 | − 0.08 | 5 48 39.39 | 37.64 | −0.63 | 37.01 |

| | *s.* | *Weight.* | |
|---|---|---|---|
| From Polaris, | *c* = −0.142, Cl. E. | 2 | *a* = −0.141, W. of S. |
| Carr. 491, | *c* = +0.014, Cl. E. | 1 | *a* = −0.022, W. of S. |
| Weighted mean.. | *c* = −0.090, Cl. E. | | *a* = −0.101, W. of S. |

Mean Δ*t*₀ (excluding high stars) = +37.007 *s.* at 2.98 *h.* ch. time.

ρ = + 0.223, losing.

## TABLE 17.

## TELEGRAPHIC LONGITUDE.

### *Detroit, Mich.—Rock Island, Ill.*

| Signals from— | Date. | Detroit. | | | Rock Island. | | | Differences of time. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Means of clock times of comparisons. | Clock corrections. | Means of sidereal times of comparisons. | Means of chronometer times of comparisons. | Chronometer corrections. | Means of sidereal times of comparisons. | Signals from Detroit. | Signals from Rock Island. | Means. |
| | 1878. | *h. m. s.* | *m. s.* | *h. m. s.* | *h. m. s.* | *h. m. s.* | *h. m. s.* | *s.* | *s.* | *s.* |
| Detroit | Sept. 26 | 23 58 10.000 | 00 23.384 | 23 57 46.616 | 17 20 19.007 | 6 07 25.341 | 23 27 44.348 | 2.268 | | |
| Detroit | Sept. 26 | 0 02 10.000 | 00 23.381 | 0 01 46.619 | 17 24 19.001 | 25.343 | 23 31 44.344 | 2.275 | | |
| Detroit | Sept. 26 | 0 14 10.000 | 00 23.373 | 0 13 46.627 | 17 36 19.015 | 25.349 | 23 43 44.364 | 2.263 | | |
| Detroit | Sept. 26 | 0 19 10.000 | 00 23.370 | 0 18 46.630 | 17 41 19.002 | 25.352 | 23 48 44.354 | 2.276 | | |
| Rock Island | Sept. 26 | 0 10 08.123 | 00 23.376 | 0 09 44.747 | 17 32 17.000 | 25.347 | 23 39 42.347 | | 2.400 | |
| Rock Island | Sept. 26 | 0 11 08.125 | 00 23.375 | 0 10 44.750 | 17 33 17.000 | 25.347 | 23 40 42.347 | | 2.403 | |
| Rock Island | Sept. 26 | 0 27 08.119 | 00 23.365 | 0 26 44.754 | 17 49 17.000 | 25.356 | 23 56 42.356 | | 2.398 | |
| Rock Island | Sept. 26 | 0 28 08.124 | 00 23.364 | 0 27 44.760 | 17 50 17.000 | 25.357 | 23 57 42.357 | | 2.403 | |
| Means for September 26 | | | | | | | | 2.271 | 2.401 | 2.336 |
| Detroit | Sept. 30 | 23 38 08.000 | 00 22.059 | 23 37 45.941 | 17 00 18.909 | 6 07 24.794 | 23 07 43.703 | 2.236 | | |
| Detroit | Sept. 30 | 23 40 08.000 | 00 22.059 | 23 39 45.941 | 17 02 18.908 | 24.793 | 23 09 43.701 | 2.240 | | |
| Detroit | Sept. 30 | 23 52 08.000 | 00 22.059 | 23 51 45.941 | 17 14 18.919 | 24.782 | 23 21 43.701 | 2.240 | | |
| Detroit | Sept. 30 | 23 52 48.000 | 00 22.059 | 23 52 25.941 | 17 14 58.905 | 24.781 | 23 22 23.686 | 2.255 | | |
| Rock Island | Sept. 30 | 23 43 08.201 | 00 22.059 | 23 42 46.142 | 17 05 19.000 | 24.790 | 23 12 43.790 | | 2.352 | |
| Rock Island | Sept. 30 | 0 02 08.195 | 00 22.060 | 0 01 46.135 | 17 24 19.000 | 24.773 | 23 31 43.773 | | 2.362 | |
| Rock Island | Sept. 30 | 0 11 08.197 | 00 22.060 | 0 10 46.137 | 17 33 19.000 | 24.765 | 23 40 43.765 | | 2.372 | |
| Rock Island | Sept. 30 | 0 16 08.173 | 00 22.060 | 0 15 46.113 | 17 38 19.000 | 24.761 | 23 45 43.761 | | 2.352 | |
| Means for September 30 | | | | | | | | 2.243 | 2.360 | 2.301 |

| | *h. m. s.* |
|---|---|
| Mean for September 26 and 30 | 0 30 02.319 |
| Relative personal equation, Adams-Powell | + 0.114 |
| Rock Island, Ill., west of Detroit, Mich | 0 30 02.433 |

## TABLE 18.

## TELEGRAPHIC LONGITUDE.

*Detroit, Mich.—Red Wing, Minn.*

| Signals from— | Date. | Detroit. |  |  | Red Wing. |  |  | Differences of time. |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  | Means of clock times of comparisons. | Clock corrections. | Means of sidereal times of comparisons. | Means of chronometer times of comparisons. | Chronometer corrections. | Means of sidereal times of comparisons. | Signals from Detroit. | Signals from Red Wing. | Means. |
|  | 1878. | *h. m. s.* | *m. s.* | *h. m. s.* | *h. m. s.* | *m. s.* | *h. m. s.* | *s.* | *s.* | *s.* |
| Detroit | Oct. 24 | 0 15 08.000 | −0 07.910 | 0 15 00.090 | 23 26 16.683 | +10 47.965 | 23 37 04.648 | 55.442 | ............ |  |
| Detroit | Oct. 24 | 15 25.000 | 07.909 | 15 17.091 | 26 33.679 | 47.965 | 37 21.644 | .447 | ............ |  |
| Detroit | Oct. 24 | 23 08.000 | 07.905 | 23 00.095 | 34 16.651 | 47.979 | 45 04.630 | .465 | ............ |  |
| Detroit | Oct. 24 | 24 08.000 | 07.905 | 24 00.095 | 35 16.648 | 47.981 | 46 04.629 | .466 | ............ |  |
| Red Wing | Oct. 24 | 26 09.549 | 07.904 | 26 01.645 | 37 18.000 | 47.984 | 48 05.984 | ............ | 55.661 |  |
| Red Wing | Oct. 24 | 29 09.565 | 07.902 | 29 01.663 | 40 18.000 | 47.989 | 51 05.989 | ............ | .674 |  |
| Red Wing | Oct. 24 | 35 18.593 | 07.890 | 35 10.694 | 46 27.000 | 48.000 | 57 15.000 | ............ | .694 |  |
| Red Wing | Oct. 24 | 39 18.509 | 07.896 | 39 10.703 | 50 27.000 | 48.007 | 0 01 15.007 | ............ | .696 |  |
| Means for October 24 | ............ | ............ | ............ | ............ | ............ | ............ | ............ | 55.455 | 55.681 | 55.568 |
| Detroit | Oct. 31 | 1 13 30.000 | −0 01.914 | 1 13 28.086 | 0 24 23.811 | +11 08.742 | 0 35 32.553 | 55.533 | ............ |  |
| Detroit | Oct. 31 | 14 22.000 | 01.913 | 14 20.087 | 25 15.800 | 08.743 | 36 24.543 | .544 | ............ |  |
| Detroit | Oct. 31 | 29 15.000 | 01.902 | 29 13.098 | 40 08.807 | 08.762 | 51 17.569 | .529 | ............ |  |
| Detroit | Oct. 31 | 30 12.000 | 01.901 | 30 10.099 | 41 05.810 | 08.763 | 52 14.573 | .526 | ............ |  |
| Red Wing | Oct. 31 | 18 14.385 | 01.911 | 18 12.474 | 29 08.000 | 08.748 | 40 16.748 | ............ | 55.726 |  |
| Red Wing | Oct. 31 | 23 14.400 | 01.907 | 23 12.493 | 34 08.000 | 08.754 | 45 16.754 | ............ | .739 |  |
| Red Wing | Oct. 31 | 34 14.469 | 01.898 | 34 12.571 | 45 08.000 | 08.768 | 56 16.768 | ............ | .803 |  |
| Red Wing | Oct. 31 | 36 16.425 | 01.897 | 36 14.528 | 47 10.000 | 08.771 | 58 18.771 | ............ | .757 |  |
| Means for October 31 | ............ | ............ | ............ | ............ | ............ | ............ | ............ | 55.533 | 55.756 | 55.645 |

No observations for personal equation between Lieutenant Powell and A. R. Flint were made. It can be approximately determined through Captain Adams and Lieutenant Lockwood.

| | *s.* |
|---|---|
| In 1876–'7 Adams observed later than Lockwood, | 0.15 (6 nights). |
| In 1875 Flint observed later than Lockwood, | 0.14 (4 nights). |
| Consequently Adams observes later than Flint, | 0.01 |
| In 1877–'8 Adams observed later than Powell, | 0.11 |
| Therefore Powell observes earlier than Flint, | 0.10 |

Mean from October 24, $0^h\ 37^m\ 55^s.568$.
Relative personal equation, Adams and Powell, +0.114.
Red Wing, west of Detroit, $0^h\ 37^m\ 55^s.682$.
Mean for October 31, $0^h\ 37^m\ 55^s.64$.
Relative personal equation, Powell and Flint, +0.10.
Red Wing, west of Detroit, $0^h\ 37^m\ 55^s.74$.
Red Wing, Minn., west of Detroit, Mich., $0^h\ 37^m\ 55^s.71$.

## TABLE 19.

## TELEGRAPHIC LONGITUDE.

*Detroit, Mich.—Louisiana, Mo.*

| Signal from- | Date. | Detroit. | | | Louisiana. | | | Differences of time. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Means of clock times of comparisons. | Clock corrections. | Means of sidereal times of comparisons. | Means of chronometer times of comparisons. | Chronometer corrections. | Means of sidereal times of comparisons. | Signals from Detroit. | Signals from Louisiana. | Means. |
| | 1878. | h. m. s. | m. s. | h. m. s. | h. m. s. | m. s. | h. m. s. | s. | s. | s. |
| Detroit | Nov. 13 | 2 21 30.000 | +00 10.660 | 2 21 40.660 | 1 49 19.901 | +00 20.740 | 1 49 40.641 | 00.019 | | |
| Detroit | Nov. 13 | 2 52 30.000 | 10.663 | 2 52 40.663 | 2 20 19.929 | 20.733 | 2 20 40.662 | 00.001 | | |
| Detroit | Nov. 13 | 2 53 30.000 | 10.663 | 2 53 40.663 | 2 21 19.931 | 20.733 | 2 21 40.664 | 59.999 | | |
| Detroit | Nov. 13 | 2 54 30.000 | 10.663 | 2 54 40.663 | 2 22 19.929 | 20.733 | 2 22 40.662 | 00.001 | | |
| Louisiana | Nov. 13 | 2 44 18.299 | 10.662 | 2 44 28.961 | 2 12 08.000 | 20.735 | 2 12 28.735 | | 00.226 | |
| Louisiana | Nov. 13 | 2 45 18.300 | 10.662 | 2 45 28.962 | 2 13 08.000 | 20.735 | 2 13 28.735 | | .227 | |
| Louisiana | Nov. 13 | 2 48 18.300 | 10.662 | 2 48 28.962 | 2 16 08.000 | 20.734 | 2 16 28.734 | | .228 | |
| Louisiana | Nov. 13 | 2 49 18.300 | 10.662 | 2 49 28.962 | 2 17 08.000 | 20.734 | 2 17 28.734 | | .228 | |
| Means for November 13 | | | | | | | | 00.005 | 00.227 | 00.116 |
| Detroit | Nov. 19 | 1 59 51.000 | +00 09.666 | 2 00 00.666 | 1 27 38.101 | +00 22.657 | 1 28 00.758 | 59.908 | | |
| Detroit | Nov. 19 | 2 00 51.000 | 09.666 | 2 01 00.666 | 1 28 38.102 | 22.657 | 1 29 00.759 | 59.907 | | |
| Detroit | Nov. 19 | 2 11 51.000 | 09.665 | 2 12 00.665 | 1 39 38.099 | 22.659 | 1 40 00.758 | 59.907 | | |
| Detroit | Nov. 19 | 2 12 51.000 | 09.665 | 2 13 00.665 | 1 40 38.098 | 22.659 | 1 41 00.757 | 59.908 | | |
| Louisiana | Nov. 19 | 2 04 21.107 | 09.666 | 2 04 30.773 | 1 32 08.000 | 22.658 | 1 32 30.658 | | 00.115 | |
| Louisiana | Nov. 19 | 2 10 21.115 | 09.665 | 2 10 30.780 | 1 38 08.000 | 22.658 | 1 38 30.658 | | .122 | |
| Louisiana | Nov. 19 | 2 15 36.145 | 09.665 | 2 15 45.810 | 1 43 23.000 | 22.659 | 1 43 45.659 | | .151 | |
| Louisiana | Nov. 19 | 2 16 36.113 | 09.665 | 2 16 45.778 | 1 44 23.000 | 22.659 | 1 44 45.659 | | .119 | |
| Means for November 19 | | | | | | | | 59.908 | 00.127 | 00.017 |

| | h. m. s. |
|---|---|
| Means for November 13 and 19 | 0 32 00.067 |
| Relative personal equation, Adams-Powell | + 0.114 |
| Louisiana, Mo., west of Detroit, Mich | 0 32 00.181 |

TABLE 20.—*Relative personal equation—Capt. H. M. Adams and Lieut. C. F. Powell.*

| Signals from— | Date. | Clock No. 256—H M. Adams, observer. | | | Chronometer No. 1541—C. F. Powell, observer. | | | Differences of time. | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Means of clock times of comparisons. | Clock corrections. | Means of sidereal times of comparisons. | Means of chronometer times of comparisons. | Chronometer corrections. | Means of sidereal times of comparisons. | Signals from clock. | Signals from chronometer. | Means |
| | 1878. | h. m. s. | m. s. | h. m. s. | h. m. s. | m. s. | h. m. s. | s. | s. | s. |
| Clock | Dec. 7 | 3 41 55.067 | +0 07.549 | 3 42 02.616 | 3 41 45.021 | +0 17.793 | 3 42 02.814 | −0.198 | | |
| Clock | Dec. 7 | 3 43 53.467 | 07.549 | 3 44 01.016 | 3 43 43.439 | 17.797 | 3 44 01.236 | −0.220 | | |
| Chronometer | Dec. 7 | 3 47 37.169 | 07.549 | 3 47 44.718 | 3 47 27.000 | 17.805 | 3 47 44.805 | | −0.087 | |
| Chronometer | Dec. 7 | 3 48 37.171 | 07.548 | 3 48 44.719 | 3 48 27.000 | 17.808 | 3 48 44.808 | | −0.089 | |
| Clock | Dec. 7 | 3 51 38.200 | 07.548 | 3 51 45.748 | 3 51 28.092 | 17.815 | 3 51 45.907 | −0.159 | | |
| Clock | Dec. 7 | 3 52 33.733 | 07.548 | 3 52 41.281 | 3 52 23.641 | 17.817 | 3 52 41.458 | −0.177 | | |
| Chronometer | Dec. 7 | 3 56 37.187 | 07.548 | 3 56 44.735 | 3 56 27.000 | 17.826 | 3 56 44.826 | | −0.091 | |
| Chronometer | Dec. 7 | 3 57 37.193 | 07.548 | 3 57 44.741 | 3 57 27.000 | 17.829 | 3 57 44.829 | | −0.088 | |
| Means for December 7 | | | | | | | | −0.189 | −0.089 | −0.139 |
| Clock | Dec. 15 | 3 42 08.000 | +0 07.207 | 3 42 15.207 | 3 41 38.106 | +0 37.167 | 3 42 15.273 | −0.066 | | |
| Clock | Dec. 15 | 3 44 08.000 | 07.210 | 3 44 15.210 | 3 43 38.111 | 37.175 | 3 44 15.286 | −0.076 | | |
| Chronometer | Dec. 15 | 3 48 37.949 | 07.214 | 3 48 45.163 | 3 48 08.000 | 37.190 | 3 48 45.190 | | −0.027 | |
| Chronometer | Dec. 15 | 3 54 37.969 | 07.220 | 3 54 45.189 | 3 54 08.000 | 37.212 | 3 54 45.212 | | −0.023 | |
| Clock | Dec. 15 | 3 58 08.000 | 07.224 | 3 58 15.224 | 3 57 38.085 | 37.225 | 3 58 15.310 | −0.086 | | |
| Clock | Dec. 15 | 3 59 08.000 | 07.225 | 3 59 15.225 | 3 58 38.076 | 37.228 | 3 59 15.304 | −0.079 | | |
| Chronometer | Dec. 15 | 4 02 37.991 | 07.228 | 4 02 45.219 | 4 02 08.000 | 37.241 | 4 02 45.241 | | −0.022 | |
| Chronometer | Dec. 15 | 4 04 37.996 | 07.231 | 4 04 45.227 | 4 04 08.000 | 37.250 | 4 04 45.250 | | −0.023 | |
| Means for December 15 | | | | | | | | −0.077 | −0.024 | −0.051 |

| | s. |
|---|---|
| Mean relative personal equation, Adams-Powell, 1878 | −0.095 |
| Correction for difference of longitude of transit posts | −0.005 |
| Powell observes earlier than Adams, 1878 (2 nights) | −0.100 |
| Powell observes earlier than Adams, 1877 (4 nights) | −0.121 |
| Personal equation to be applied to longitude work of 1878 Powell west of Adams | −0.114 |

TABLE 21.—*Geographical positions.*

| Station. | Description of reference points. | Latitude. | | | Longitude W from Greenwich. | | |
|---|---|---|---|---|---|---|---|
| | | ° | ′ | ″ | ° | ′ | ″ |
| Rock Island, Ill.... | Astronomical post-stone 20 by 17 inches, and 18 inches above ground, on United States arsenal grounds. | 41 | 31 | 03.41 | 90 | 33 | 40.10 |
| | Southeast corner of guard-house ................. | 41 | 31 | 01.51 | 90 | 33 | 45.99 |
| | Gas-pipe △ 2, Rock Island Rapids, improvement survey. | 41 | 31 | 03.69 | 90 | 33 | 40.39 |
| Red Wing, Minn... | Astronomical post-stone 20 by 20 inches, and 18 inches above ground, near northwest corner of county court-house yard. | 44 | 33 | 44.16 | 92 | 31 | 59.25 |
| | Spire of Catholic church........................ | 44 | 33 | 44.64 | 92 | 31 | 49.66 |
| Louisiana, Mo ..... | Astronomical post-stone northwest corner of high-school yard. | 39 | 27 | 14.30 | 91 | 03 | 06.30 |
| | Northeast corner of high-school building....... | 39 | 27 | 12.64 | 91 | 03 | 08.18 |
| | Southeast corner of brick residence, northwest corner of Noyles and Fourth streets. | 39 | 27 | 15.25 | 91 | 03 | 07.42 |

## APPENDIX No. 2.

## MAGNETIC WORK.

### REPORT OF LIEUTENANT D. W. LOCKWOOD, CORPS OF ENGINEERS.

DETROIT, MICH., *July* 3, 1879.

SIR: In compliance with instructions received from you, I have the honor to make the following report on the instruments used by Lieut. C. F. Powell, Corps of Engineers, in his magnetic work of 1878, and to describe the method of observing followed by him as shown by his notes.

The stations occupied were Rock Island, Ill., Red Wing, Minn., and Louisiana, Mo.

At Rock Island and Red Wing the observations included those for declination, dip, and intensity, while at Louisiana observations for horizontal intensity were not taken, and the observations for declination were a failure, the range for three days' work being more than 1°, and no two days' work agreeing within the required limit of 10′; the range in dip was also much in excess of that prescribed.

The instruments used were the Jones combined declinometer and magnetometer, and Barrow dip-circle No. 26.

The former when used as a declinometer has its reading telescope mounted on a separate stand from that supporting the magnet box. A small theodolite set up on its tripod about 18 inches from the north end of the magnet being used for this purpose. When used as a magnetometer for horizontal intensity, a reading telescope is fastened to one of the arms projecting from the base supporting the magnet box and turning with it. To the opposite arm a counterpoise weight is attached.

The declination magnets are as follows:

1°. Magnet X, a hollow steel cylinder 4.03$^{\text{in}}$ long by $\frac{7}{16}$ inch external diameter. At the south end is a glass scale. Value of 1 div. about 2′.15. At the north end an achromatic lens adjusted at such a distance from the scale that the scale is most distinctly visible when the reading telescope is adjusted to stellar focus. The value of 1 div. of scale is affected by a change in the position of the lens.

2°. A hollow brass cylinder 4$^{\text{in}}$ long and $\frac{7}{16}$ inch diameter, with a weak magnet inside of it, its axis firmly fixed parallel with the axis of the cylinder; it is also fitted with scale and lens.

The intensity magnet is marked D 5, and consists of a hollow steel cylinder 3$^{\text{in}}$.75 long and $\frac{3}{16}$ inch external diameter. It is fitted at one end with an adjustable balancing ring. This ring is easily displaced, so that the movement of inertia of this magnet and its stirrup should be determined at each station, and great care taken to avoid displacing the ring while the magnet is being used. This magnet has no scale.

The suspended magnet in deflections marked at north end $\frac{b}{8}$, is 3$^{\text{in}}$.0 long and $\frac{3}{16}$ inch external diameter. It is fastened to a small stirrup with a mirror below the magnet. The scale for determining the angle of deflection is 6$^{\text{in}}$ long, and attached to the reading telescope near its eye end. Value of 1 div. of scale, about 10′.

In using this instrument, the deflecting or intensity magnet is fixed in the magnetic prime vertical.

In the computation "P" is assumed a equal to zero; "$q$" the temperature co-efficient is also taken as zero.

The range of temperature in deflection experiments and vibrations was also quite large, but the values of "*q*" as deducted from the different sets had contrary signs.

In taking dip observations the needles showed that a preponderance existed, and on account of the extreme range the north end not always being below the horizontal. Mayer's formula, given in Schott's notes on measurements of terrestrial magnetism, was used in the computation.

The note-book shows that observations to determine local attraction were made only at Rock Island. The true meridian in every case was determined by the astronomical transit or zenith telescope.

The values of the declination, given in the table appended hereto for each day, are the means of the morning or eastern elongation, and the afternoon or western elongation, the mean of the eastern and western elongations for each day being corrected for daily range.

Very respectfully, your obedient servant,

D. W. LOCKWOOD,
*First Lieutenant of Engineers.*

Maj. C. B. COMSTOCK,
*Corps of Engineers.*

Magnetic declination.

| tion. | Dates, [illegible] Day. | Time of elongation. | Declination at elongation. | Mean of elongation. | Daily range. | [illegible] | [illegible] | [illegible] | |
|---|---|---|---|---|---|---|---|---|---|
| | | h. m. | ° ′ ″ | ° ′ ″ | ′ ″ | ″ | ° ′ ″ | | |
| Rock Island, Ill | Sept. 15 | 8 15 a. m. | 7 01 04.5 | | | | | | |
| | Sept. 15 | 1 35 p. m. | 6 55 10.5 | 6 58 07.5 | 5 54 | 15.6 | 6 57 51.9 | | |
| | Sept. 16 | 8 50 a. m. | 6 59 14 | | | | | | |
| | Sept. 16 | 1 25 p. m. | 6 54 58.6 | 6 57 06.2 | 4 15.4 | - 11.2 | 6 56 55.1 | | |
| | Sept. 17 | 9 25 a. m. | 7 03 00 | | | | | | |
| | Sept. 17 | 1 25 p. m. | 6 55 03.3 | 6 59 01.6 | 7 56.7 | — 21.0 | 6 58 40.6 | 6 57 52 | |
| Red Wing, Minn | Oct. 10 | 8 55 a. m. | 7 56 52.7 | | | | | | |
| | Oct. 10 | 1 00 p. m. | 7 43 22.7 | 7 50 07.7 | 13 30 | — 1 16.6 | 7 48 51.1 | | |
| | Oct. 11 | 8 00 a. m. | 7 56 19.2 | | | | | | |
| | Oct. 11 | 0 50 p. m. | 7 46 18.7 | 7 51 19.0 | 10 00.5 | — 57.6 | 7 50 21.4 | 7 49.60 | |
| Louisiana, Mo | | | | | | | | | Observations were taken here, but from local attraction or other causes were not comparable. |

*Note from Lieut. Powell's note-book, p.* 122, "*S*" *No.* "41."

Declination observations made on 25th made as check on results of previous days, which differed greatly. It was supposed that large error in reading horizontal limb or pointing to mark had been made; a third set would show which of preceding sets was the correct one. Doubt still existing, however, more observations were not made, as at least two days' work would be required. Instructions would not warrant this delay. No declination, therefore, at Louisiana.

Lieutenant LOCKWOOD and Lieutenant PRICE, *Computers.*

*Dip and intensity.—Lieutenant Powell, observer.*

[Barrow dip-circle for dip.]

| Station. | Horizontal intensity = X. | | | | | Dip = θ. | | | | Total intensity = φ. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Date. | v. | "m." | "X." | Mean "X." | Date. | Needle. | Dip. | Means. | | |
| | 1878. | *Feet.* | | | | 1878. | | ° ′ ″ | ° ′ ″ | | |
| Rock Island, Ill | Sept. 19 | 1.17 | 0.26920 | 4.20204 | | Oct. 5 | No. 1 | 72 20 00 | | | $\phi = X \sec. \theta$. |
| | Sept. 20 | 1.17 | .27001 | 4.21646 | | Oct. 5 | No. 2 | 72 30 12 | | | |
| | Sept. 19 | 1.33 | .26896 | 4.20586 | | Oct. 7 | No. 1 | 71 55 35 | | | |
| | Sept. 20 | 1.33 | .27061 | 4.20722 | 4.20790 | | | | 72 15 16 | 13.80588 | |
| Red Wing, Minn | Oct. 23 | 1.20 | 0.27290 | 3.67114 | | Oct. 23 | No. 2 | 74 20 37 | | | Needle No. 1 found to have its axis loose. |
| | Oct. 24 | 1.20 | .26777 | 3.67789 | | Oct. 24 | No. 2 | 74 16 38 | | | |
| | Oct. 23 | 1.33 | .27107 | 3.69590 | | Oct. 26 | No. 2 | 74 06 04 | | | |
| | Oct. 24 | 1.33 | .26814 | 3.67290 | 3.67946 | | | | 74 14 26 | 13.54740 | |
| Louisiana, Mo | No observations of deflection or oscillation | | | | | Nov. 20 | No. 2 | 69 38 31 | | | |
| | | | | | | Nov. 21 | No. 2 | 69 53 50 | | | |
| | | | | | | Nov. 22 | No. 2 | 70 17 51 | | | |
| | | | | | | Nov. 22 | No. 2 | 70 00 30 | 69 57 41 | | |

Lieutenant LOCKWOOD and Lieutenant PRICE, *computers.*

## APPENDIX No. 3.

### SURVEY OF THE MISSISSIPPI RIVER.

### REPORT OF LIEUTENANT D. W. LOCKWOOD, CORPS OF ENGINEERS.

DETROIT, MICH., *June* 14, 1879.

SIR: I have the honor to submit the following report of work done on the survey of the Mississippi River during the winter of 1878-'79.

On the 18th of October, 1878, I received orders from you to proceed to New Albany, Ind., and receive such property as might be sent from Detroit to that point for the outfit of the quarter boats that had been built there during the summer, to purchase articles needed to complete their outfit, and arrange to have them taken to Memphis, Tenn., as soon as the yellow fever should cease.

I reached New Albany October 22, and found the quarter boats ready to be taken down the river as soon as the necessary arrangements could be made. The property sent from Detroit having arrived, the articles needed to complete the outfit of the boats, in connection with the property in store at Memphis, were purchased, and in addition one month's supplies for all the parties.

The stern-wheel steamer Little Eagle, hired for the season of McDonald Brothers, at Saint Louis, by Captain Adams, reached New Albany at noon November 15. The boats, four in number, were taken in tow, and she proceeded down the river at once, reaching Memphis on the morning of November 21.

Lieutenant Price, Corps of Engineers, had already reached Memphis, and had had the old quarter-boat Arkansas towed up from Fort Pickering to the steamboat landing. The property that had been stored with Rose & Co., at the close of the preceding season's work, was put on board the proper boats, and on the 24th the steamer started down the river with the fleet in tow. The parties were as follows:

| Chief of parties. | Duty. | Boat. |
|---|---|---|
| Lieutenant Price | Triangulation | Louisiana. |
| Assistant Engineer Wisner | do | Do. |
| Assistant Engineer L. L. Wheeler | Precise levels | Pioneer. |
| Assistant Engineer Ockerson | Topographical | Tennessee. |
| Assistant Engineer Darling | do | Mississippi. |
| Assistant Engineer Eisenmann | do | Arkansas. |

The organization on the Louisiana comprised two complete triangulation parties, that of Lieutenant Price and that of Assistant Engineer Wisner; as both these parties remained during the season on the Louisiana, Lieutenant Price had immediate charge of both.

The instructions required the sounding to be done at a low stage of river, and also required that the section of the river between Austin and Delta be surveyed, as follows, for the Mississippi Board of Engineers:

The shore line and outline of bars to be run, a line of levels to be carried down one bank, and river slope determined, in addition to sounding. Assistant Engineer Ockerson was assigned to this work.

Assistant Engineer Darling and his party, on the Mississippi, were left at Scanlon's Landing to do the soundings, run the shore line of bars, and determine the low-water slope between that point and Commerce Landing.

Lieutenant Price and triangulation parties, on the Louisiana, were left at Norfolk, to carry the triangulation from the line △ Fairview—△ State line south.

Assistant Engineer Eisenmann and his party, on the Arkansas, were left at Commerce, to do the sounding, run the shore line of bars, and determine the low-water slope between that place and Austin.

Assistant Engineer L. L. Wheeler and his leveling party, on the Pioneer, were left at Austin Landing, to carry the precise levels from this point, where the work of the previous year stopped, to the south.

Assistant Engineer Ockerson and his party, on the Tennessee, were left near O. K. Landing, to survey the section of the river between Austin and Delta, as mentioned above.

Mr. Ockerson also had charge of sediment work during the season, and made the soundings in relation to sand wave determinations.

When the soundings, &c., had been finished the instructions required that the topographical parties should commence the regular work of the survey at Scanlon's Landing, where the work of the previous year stopped, and carry it down the river. Assistant Engineer Eisenmann, having completed the soundings, &c., of his section to the foot of Bordeaux Chute, was, December 24, taken up the river. [illegible]

Assistant Engineer Darling had by this time completed the work required between Scanlon's Landing and Commerce, and was taken up the river at the same time; his boat was left at the government light, a short distance below Scanlon's Landing, while Mr Eisenmann's boat was left near foot of Cat Island (No. 50).

Assistant Engineer Ockerson, having finished the work required by the Board of Engineers, was, on January 24, 1879, moved up the river to a point on the Arkansas shore 2 miles below Bennett's Landing.

The sections required for observations concerning sand-waves were located as follows:

1°. The deep-water section near Trotter's Field Landing, 2¼ miles above Helena.

2°. The shoal-water section just below the town.

Five lines 100 meters apart were fixed for each section, and soundings taken on them by Mr. Ockerson and party; 1°, December 27 and 28, 1878; 2°, January 21 and 23, 1879.

The party on the steamer was under my personal supervision, and consisted of Francis Devroe, foreman and acting mate, and four men. When the steamer was not engaged in moving or supplying the different parties or occupied with section work, this party was used in making borings. The steamer was laid up nearly a week in Memphis during December, having her shaft repaired. From January 1 to 16, the weather was so cold that no boring could be done, and from the morning of January 4th to the 13th the boat was frozen in the ice above Bordeaux Chute.

On January 15 the Mississippi was cut down and sunk by the ice. When the extreme cold weather set in, about January 1, the river was falling, and continued to do so until about the 11th or 12th, when it turned, and for some time rose at the rate of about 2 feet per diem. The Mississippi was towed up to the landing, and left on a little shelvy bar just above it. The high-water prevented anything more being done to her until February 24, when the river had gone down, so as to leave her damaged side exposed. Carpenters were then put at work on her, but before the work could be completed the river rose again, and the hole was patched temporarily. On March 1 she was towed up to Fort Pickering and hauled out on the shore, so that the job could be completed. At present her hull is in good condition. The hole cut in her side was. 44 feet long and 8 inches wide. One side of her cabin was very much torn up by the ice, but still she can be repaired, so as to be of further use when required.

The cold weather already spoken of interfered considerably with work of all kinds, while the high-water which followed soon after, overflowing the low-lands and filling the swamps and bayous, almost stopped every thing. The highest water during the season was on January 29, when the Memphis gauge read 28 feet 11 inches.

During the fore part of March the atmosphere was very unfavorable for reading angles, on account of smoke from burning over old cotton-fields, and as Lieutenant Price reported that but little or no progress could be made with the triangulation, the Louisiana was taken to Memphis March 6, and laid up.

The Tennessee was taken up on the 7th and the Arkansas on the 10th. Mr. Darling's party had been moved up on the 28th of February. Assistant Engineer L. L. Wheeler, having carried the precise levels as far as Friar's Point, was taken up the river to Norfolk Landing February 7, and directed to report with his party to Assistant Engineer Darling for topographical duty. His party was discharged, and he was ordered to Detroit a few days before Mr. Darling was moved to town.

On January 29 I had the honor, in complying with the instructions of your letter of January 14, to submit a plan for organizing and maintaining a party to be left at or near Helena during the summer to continue the sediment observations and cross-section work; in it I recommended that Mr. J. B. Johnson be put in charge of the party, and that Mr. Childs be retained as recorder; also that the party be quartered on the Pioneer.

My plan having been approved in your letter of February 8, the Pioneer was furnished, upon Mr. Johnson's requisition, with the necessary outfit from the other boats, and on March 10 Mr. Johnson started down the river with her.

There being no further work for the steamer, she was sent up the river to Saint Louis on the 11th of March. On the same date I left Memphis for Detroit, arriving here on the 14th.

The work accomplished during the season may be summed up as follows:

*Triangulation.*—From line △ Fairview—△ State Line to 2 miles above Helena, a distance of about 50 miles, Assistant Engineer Wisner measured a secondary base line at Harbert's Point, one mile long, and made the necessary comparisons between the tubes used in the measurement and the standard iron 15-feet bar. Lieutenant Price determined the azimuth of the base and connected it with the triangulation.

*Precise levels.*—From Austin to Friar's Point, a distance of 27 miles, work was done in duplicate. At Helena levels were carried across the river, and the gauge at that point connected with the Memphis gauge. Permanent bench-marks were established when necessary. Some of the work was done in quadruplicate, but is counted in as only done in duplicate.

*Topography.*—From Scanlon's Landing to Mrs. Baldwin's, below Commerce cut-off, a distance along the main channel of the river, according to Major Suter's map, of 26 miles. The survey of Council Bend shows 14 miles more, or 40 miles in all. The contour planes were taken 5 feet apart instead of 3 feet, as was the case last year.

*Hydrography.*—For the regular survey extended from Scanlon's Landing to Walnut Bend Landing, foot of Bordeaux Chute, a distance of 36 miles down the main channel, or with Council Bend, making 50 miles in all.

The section of river from Austin to Delta, surveyed by Mr. Ockerson, covered 25 miles. The work consisted in running the shore-line of banks and bars, sounding, determining water-slope, and carrying a duplicate line of levels down one bank.

*Water-slope.*—This was determined for short stretches of river, and was done at the same time the sounding was being done.

*Sediment.*—This work was commenced November 28, and continued throughout the season.

*Sand-wave observations.*—This work, as already stated, was done by Mr. Ockerson's party, and consisted in sounding the 10 lines, 5 in each section—Trotter's and Helena twice.

Borings were made as follows: Near △ Watson's, abreast of Horn Lake bar, on Tennessee side of the river; on sand bar in Montezuma Bend; on Mississippi side of river at Harbert's Point; a short distance south of saw-mill below Helena, abreast of head of towhead in Montezuma Bend, on Arkansas side of the river.

Very respectfully, your obedient servant,

D. W. LOCKWOOD,
*First Lieutenant of Engineers.*

Maj. C. B. COMSTOCK,
*Corps of Engineers.*

## BORING.

The apparatus used during the past season was the ordinary drive-well described in previous reports. The apparatus proper worked very well. Once the threads in the steel driving-cap were stripped and had to be recut. The old pipe that had been in use for the two preceding seasons was well nigh worthless, the iron from repeated driving and pounding having become very granular in its structure, so that the threads on the ends of the sections frequently stripped or broke short off in the unions while being driven. This caused a good deal of delay. A pipe stock and die were purchased and found of great service. In cutting threads on the sections great care should be taken in centering the pipe in the die so that the sections will join in a straight line.

The driving point and socket were lost at Cairo, in the early winter of 1877, and have never been replaced. This should be done before any more work is done with the apparatus, as in driving through coarse gravel the point is absolutely necessary. In ordinary soil no point is needed.

The following tables show the strata passed through in each well and the size of the particles at different depths.

### BORING No. 1.—*Close to water and* 204 *meters above* △ *Watson.*

[Reference of site, 198.8 feet; of bottom, 122.3 feet.]

| Depth. | Material. | Size of particles. | Remarks. |
|---|---|---|---|
| *Feet.* | | | |
| 10 | Sand | 10 per cent. less than 0.002 inch | Same as at surface. |
| | | 30 per cent. between 0.002 inch and 0.01 inch | Light color; siliceous. |
| | | 60 per cent. between 0 01 inch and 0.02 inch | |
| 26 | ....do | 10 per cent. less than 0.005 inch | Light color; siliceous. |
| | | 25 per cent. between 0.005 inch and 0.015 inch | |
| | | 65 per cent. between 0.015 inch and 0.03 inch | |
| 26 to 27 | Blue clay stratum about 1 foot thick; then sand again | | |
| 40 | Sand | 25 per cent. less than 0.005 inch | Dark color; siliceous. |
| | | 50 per cent. between 0.005 inch and 0.015 inch | |
| | | 25 per cent. between 0.015 inch and 0.025 inch | |
| 52 | ....do | 30 per cent. less than 0.005 inch | |
| | | 40 per cent. between 0.005 inch and 0.01 inch | |
| | | 30 per cent. between 0.01 inch and 0.025 inch | |
| 58 | ....do | 5 per cent. less than 0.005 inch | Occasional grains 0.03 inch. |
| | | 45 per cent. between 0.005 inch and 0.015 inch | |
| | | 50 per cent. between 0.015 inch and 0.025 inch | |
| 64 | ....do | 70 per cent. between 0.005 inch and 0.01 inch | |
| | | 30 per cent. between 0.01 inch and 0.015 inch | |
| 70 | ....do | 40 per cent. between 0.005 inch and 0.015 inch | Sand grows coarser as hole gets deeper. |
| | | 60 per cent. between 0.015 inch and 0.11 inch | |

The total depth of the well was 76.5 feet. At 72 feet a cottonwood log was struck, and the head of the pipe had its threads stripped by the steel driving-cap at 76.5 feet.

Boring made November 29 and 30, 1878.

Bottom of well 37 feet below bottom of river.

### BORING No. 2.—*On sand bar in Montezuma Bend, located on Mr. Ockerson's Field Sheet No.* 12.

[Reference of site, 167.2 feet; of bottom, 104.2 feet.]

| Depth. | Material. | Size of particles. | Remarks. |
|---|---|---|---|
| *Feet.* | | | |
| 12 | Sand | 35 per cent. less than 0.005 inch | Sand from surface down same. |
| | | 50 per cent. between 0.005 inch and 0.01 inch | |
| | | 15 per cent. between 0.01 inch and 0.02 inch | |
| 18 | ....do | 25 per cent. between 0.01 inch and 0.02 inch | Same to 20 feet. |
| | | 55 per cent. between 0.005 inch and 0.01 inch | |
| | | 20 per cent. less than 0.005 inch | |
| 20 to 22 | Blue clay; sand similar to above mixed with it | | |
| 24 | Sand | 10 per cent. between 0.01 inch and 0.02 inch | |
| | | 15 per cent. between 0.005 inch and 0.01 inch | |
| | | 75 per cent. less than 0.005 inch | |
| 30 | ....do | 5 per cent. between 0.01 inch and 0.02 inch | |
| | | 15 per cent. between 0.005 inch and 0.01 inch | |
| | | 80 per cent. less than 0.005 inch | |
| 36 | ....do | 70 per cent. between 0.01 inch and 0.02 inch | Occasional grains 0.2 inch or 0.3 inch diameter. |
| | | 15 per cent. between 0.005 inch and 0.01 inch | |
| | | 15 per cent. less than 0.005 inch | |
| 42 | ....do | 30 per cent. greater than 0.02 inch up to 0.05 inch | |
| | | 50 per cent. between 0.01 inch and 0.02 inch | |
| | | 20 per cent. less than 0.01 inch | |
| 48 | ....do | 10 per cent. between 0.02 inch and 0.03 inch | |
| | | 60 per cent. between 0.01 inch and 0.02 inch | |
| | | 30 per cent. less than 0.01 inch | |
| 54 | ....do | 25 per cent. between 0.01 inch and 0.02 inch | |
| | | 50 per cent. between 0.005 inch and 0.010 inch | |
| | | 25 per cent. less than 0.005 inch | |
| 60 | ....do | Same as above | |

At 63 feet the pipe struck a cottonwood log and had to be withdrawn; a piece of the log 12 inches long was brought up cut square across the grain. The water was falling so fast that there was danger of the boat grounding, and in addition the weather turned very cold, so that boring in this locality was abandoned.

Work done December 30 and 31, 1878.

Boring extended to within 11 feet of river bottom abreast of the boring site.

### BORING No. 3.—*At Harbert's Point,* 200 *meters above* △ *Shoo Fly.*

[Reference of site, 194.2 feet; of bottom of well, 94.2.]

| Depth. | Material. | Size of particles. | Remarks. |
|---|---|---|---|
| *Feet.* | | | |
| 0 to 6 | Mold | Silt and surface deposit | |
| 6 to 12 | Brown clay and silt | | |
| 12 to 18 | Blue clay | | |
| 18 to 24 | Brown sand | 20 per cent. between 0.01 inch and 0.015 inch | |
| | | 25 per cent. between 0.005 inch and 0.01 inch | |
| | | 55 per cent. less than 0.005 inch | |
| 24 to 30 | ......do | 40 per cent. between 0.01 inch and 0.02 inch | |
| | | 30 per cent. between 0.005 inch and 0.01 inch | |
| | | 30 per cent. less than 0.005 inch | |
| 36 | Gray sand | 50 per cent. between 0.01 inch and 0.02 inch | |
| | | 50 per cent. less than 0.01 inch | |
| 42 | ......do | 40 per cent. between 0.01 inch and 0.015 inch | Mixed with silt. |
| | | 60 per cent. less than 0.01 inch | |
| 48 | ......do | Same as above | |
| 54 | ......do | 10 per cent. between 0.01 inch and 0.015 inch | Very little silt. |
| | | 45 per cent. between 0.005 inch and 0.01 inch | |
| | | 45 per cent. less than 0.005 inch | |
| 60 | Sand | 5 per cent. between 0.01 inch and 0.015 inch | |
| | | 45 per cent. between 0.005 inch and 0.01 inch | |
| | | 50 per cent. less than 0.005 inch | |
| 100 | ......do | 50 per cent. between 0.01 inch and 0.02 inch | |
| | | 30 per cent. between 0.005 inch and 0.01 inch | |
| | | 20 per cent. less than 0.005 inch | |

From 60 feet down to 100 feet the material brought up was pure sand, quite regular in size.

The above-described well was commenced January 30, but the upper end of the pipe broke off after the pipe was down 18 feet. During the 31st the upper threads were stripped several times, and on February 1 the steel driving-cap was taken to Memphis to be upset and have a new thread cut in it. Boring was resumed on February 4, and completed on the 7th.

Boring extended 9 feet below river bottom.

### BORING NO. 4.—*Forty feet above △ 40 (Ockerson).*

[Reference of site, 190.3 feet; reference of bottom of well, 105.3 feet.]

| Depth. | Material. | Size of particles. | Remarks. |
|---|---|---|---|
| *Feet.* | | | |
| 0 to 6 .. | Surface soil and mud; drab color. | ........................................ | |
| 6 to 16 . | Blue clay; free from sand. | ........................................ | |
| 16 .. | ......do ........................ | ........................................ | |
| At 24 .. | ......do ........................ | ........................................ | |
| At 30 .. | ......do ........................ | ........................................ | |
| At 36 .. | ......do ........................ | ........................................ | |
| At 42 .. | ......do ........................ | ........................................ | |
| At 48 .. | ......do ........................ | ........................................ | |
| At 54 .. | ......do ........................ | Some sand; none greater than 0.005 inch ...... | |
| At 80 .. | Sand and blue clay ........ | 10 per cent. larger than 0.01 inch ..............<br>70 per cent. between 0.005 inch and 0.01 inch ..<br>20 per cent. less than 0.005 inch ............... | |
| At 85 .. | Rock ...................... | Bed rock .......................................... | |

The progress of the pipe was stopped at 85 feet. Upon drawing it up, the bottom section for a length of 2 feet was found to be split and the bottom very much battered. The lower part of the pipe was filled with clay, decomposed rock, and fragments of the rock itself, containing fossil shells.

Rock, arenacious-greenish color, especially when wet.

This work was done February 11 and 12, 1879.

The bottom of the well was 23 feet below the river bottom.

### BORING NO. 5.—*Abreast of head of Montezuma Towhead, on Arkansas side of river.*

[Reference of site, 182.0 feet; reference of bottom of well, 87.0 feet.]

| Depth. | Material. | Size of particles. | Remarks. |
|---|---|---|---|
| *Feet.* | | | |
| 0 to 6 .. | Brown clay ......... | No sand .............................................. | Reference of zero of gauge at Helena, 148.9 feet. Distance from gauge to boring site, 6 miles. River slope, 0.40 feet per mile. Reading of Helena gauge, Feb. 20, 28.5 feet. Distance from plane of boring site to water surface, Feb. 20, 7 feet. |
| At 12 .. | ....do ............... | Some sand; 5 per cent. over 0.005 inch ............ | |
| At 18 .. | ....do ............... | Some sand; none over 0.005 inch .................. | |
| At 24 .. | Sand.................. | 50 per cent. between 0.005 inch and 0.01 inch .......<br>50 per cent. less than 0.005 inch ..................... | |
| At 30 .. | ....do ............... | 70 per cent. between 0.005 inch and 0.01 inch .......<br>30 per cent. less than 0.005 inch ..................... | |
| At 36 .. | ....do ............... | Same as at 30 feet ........................................ | |
| At 42 .. | ....do<br>And some clay....... | 30 per cent. larger than 0.01 inch .....................<br>40 per cent. between 0.005 inch and 0.01 inch .......<br>30 per cent. less than 0.005 inch ..................... | |
| At 48 .. | Same ............... | 40 per cent. between 0.01 inch and 0.02 inch .......<br>30 per cent. between 0.005 inch and 0.01 inch .......<br>30 per cent. less than 0.005 inch ..................... | |
| At 95 .. | Same ............... | 60 per cent. between 0.02 and 0.05 inch ............<br>20 per cent. between 0.01 and 0.02 inch ............<br>20 per cent. less than 0.01 inch ....................... | |

This boring was made February 19 and 20. The pipe parted while being drawn up, 42 feet remaining in the ground. In hauling up the pipe the jack-screws were generally used to get up one length, then the clamp was fastened on, and pry-poles used. The boring extended 61 feet lower than the river bottom in the chute; 23 feet lower than the main river bottom abreast of the site. The river bottom at Delta was 7 feet lower than bottom of well.

## SEDIMENT.

Observations to determine the amount of sediment in water at surface and at one foot from the bottom of the river were commenced November 28, and continued throughout the season. As stated before, Mr. Ockerson had charge of this work.

The instructions under which the work was done were as follows:

"To get average values: Surface samples will, when practicable, be taken at about ¼ and ¾ the width of the river. These will be mixed, and the samples to be kept will be taken from their mixture. The same for bottom water. Surface and bottom waters are, of course, always to be kept separate, but are to undergo the same treatment. * * *

"On shore; having thoroughly stirred up the surface water so that the coarse grains are held in suspension, take a known volume of it, a little less than one-fifth the volume of the holder, and put it into a large fruit-jar or other convenient holder. * * * Five days' samples of equal values (one sample being taken on each day) should nearly fill one jar, which will then be set aside to settle till its water is nearly or quite clear. * * *

"The water in a jar having become nearly or quite clear, the clear water is siphoned off, and what remains in the jar is poured on a filter-paper, using two if one tears, the jar rinsed with a little clear water, and the rinsings poured on the filter-paper. The filtrate and filter-paper are allowed to dry thoroughly in company with a clean filter-paper of the same size (weight?) and quality. Then the filtrate with its paper is weighed, and also the clean filter-paper. The latter weight subtracted from the former gives the weight of the sediment."

Trouble was found in getting a bucket that would work well in getting bottom water. The results obtained for sediment at the bottom of the river indicate that in many cases sand and mud, stirred up by the bucket striking the bottom, were brought up, thus rendering those results worthless. The observations were made from Austin to Delta and in the vicinity of Bennett's Landing and Commerce. The measured quantity taken each day was 100 grammes, so that in the table following the column marked "sediment" shows the amount of sediment in 500 grammes of water. The bottom sediment is not given.

### SEDIMENT OBSERVATIONS.

**Note.**—In the following notes the omissions marked thus (×) were made because no confidence is placed in the results, as the apparatus used for obtaining bottom specimens did not work satisfactorily.

| No. of observation. | Dates. | Depth. | Weight of water. | Weight of sediment. | Proportion of sediment to water by weight. | Per cent. of particles by diameter. | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Inches, .0 to .002. | Inches, .002 to .005. | Inches, .005 to .01. | |
| | | | *Millig's.* | | | | | | |
| 1 | Dec. 13 to 17, incl.... | Surface.. | 500,000 | 288.8 | $\frac{1}{1731}$ | 25 | 40 | 35 | |
| | | Bottom.. | 500,000 | 303.8 | $\frac{1}{1646}$ | 80 | 20 | .... | |
| 2 | Dec. 18 to 22, incl.... | Surface.. | 500,000 | 260.8 | $\frac{1}{1917}$ | 40 | 40 | 20 | |
| | | Bottom.. | 500,000 | 305.0 | $\frac{1}{1639}$ | 100 | .... | .... | |
| 3 | Dec. 23 to 27, incl.... | Surface.. | 500,000 | 218.8 | $\frac{1}{2285}$ | 60 | 40 | .... | |
| | | Bottom.. | 500,000 | 238.1 | $\frac{1}{2100}$ | 55 | 30 | 15 | Pieces of glass found. |
| 4 | Dec. 28 to Jan. 1, incl. | Surface.. | 500,000 | 174.2 | $\frac{1}{2870}$ | 80 | 20 | .... | |
| | | Bottom.. | 500,000 | 202.5 | $\frac{1}{2469}$ | 60 | 30 | 10 | |
| 5 | Jan. 2 to 6, incl...... | Surface.. | 500,000 | 198.2 | $\frac{1}{2523}$ | 40 | 50 | 10 | On last two dates the specimens were taken from only one side of the river. Running ice prevented crossing. |
| | | Bottom.. | 500,000 | ........ | ..... | .... | .... | .... | |
| 6 | Jan. 7 to 11, incl..... | Surface.. | 500,000 | 192.6 | $\frac{1}{2596}$ | 60 | 40 | .... | |
| | | Bottom.. | 500,000 | 240.5 | $\frac{1}{2079}$ | 40 | 40 | 20 | See No. 5. |
| 7 | Jan. 12 to 16, incl.... | Surface.. | 500,000 | 213.2 | $\frac{1}{2345}$ | 85 | 15 | .... | Specimens of 12th, 13th, and 15th were taken only on one side of river. Ice (see note at 5). |
| | | Bottom.. | .......... | (×) | ...... | .... | .... | .... | |
| 8 | Jan. 17 to 21, incl.... | Surface.. | 500,000 | 481.5 | $\frac{1}{1038}$ | 100 | .... | .... | First bottom filter-paper broke and sediment not all washed off. |
| | | Bottom.. | .......... | (×) | ...... | .... | .... | .... | |
| 9 | Jan. 22 to 26, incl.... | Surface.. | 500,000 | 394.0 | $\frac{1}{1269}$ | 90 | 10 | .... | |
| | | Bottom.. | .......... | (×) | ...... | .... | .... | .... | |
| 10 | Jan. 27 to 31, incl.... | Surface.. | 500,000 | 332.5 | $\frac{1}{1504}$ | 100 | .... | .... | |
| | | Bottom.. | .......... | (×) | ...... | .... | .... | .... | |
| 11 | Feb. 1 to 5, incl...... | Surface.. | 500,000 | 223.3 | $\frac{1}{2239}$ | 95 | 5 | .... | |
| | | Bottom.. | .......... | (×) | ...... | .... | .... | .... | |
| 12 | Feb. 6 to 10, incl..... | Surface.. | 500,000 | 232.0 | $\frac{1}{2155}$ | 100 | .... | .... | |
| | | Bottom.. | .......... | (×) | ...... | .... | .... | .... | |
| 13 | Feb. 11 to 15, incl.... | Surface.. | .......... | 515.3 | ...... | .... | .... | .... | By mistake the surface specimens of 14th and 15th were put in bottom jar. |
| | | Bottom.. | .......... | 360.6 | ...... | .... | .... | .... | |
| 14 | Feb. 16 to 20, incl.... | Surface.. | 500,000 | 205.7 | $\frac{1}{2431}$ | 100 | .... | . | |
| | | Bottom.. | .......... | (×) | ...... | .... | .... | .... | |

*Sediment observations*—Continued.

| No. of observation. | Dates. | Depth. | Weight of water. | Weight of sediment. | Proportion of sediment to water by weight. | Per cent. of particles by diameter. | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Inches, .0 to .002. | Inches, .002 to .005. | Inches, .005 to .01. | |
| | | | *Millig's.* | | | | | | |
| 15 | Feb. 21 to 25, incl .... | Surface.. | 500, 000 | 168. 4 | $\frac{1}{2969}$ | .... | .... | .... | Thrown out; some accident; sand too large. The top of bottom jar was broken and glass got in and could not be separated. |
| | | Bottom.. | ......... | ......... | ...... | .... | .... | .... | |
| 16 | Feb. 25 to Mar. 1, incl. | Surface.. | 500, 000 | 136. 0 | $\frac{1}{3677}$ | 30 | 30 | 20 | 20 per cent. >0.01 inch. |
| | | Bottom.. | ......... | (×) | ...... | .... | .... | .... | |
| 17 | Mar. 2 to 6, incl...... | Surface.. | 559, 500 | 169. 1 | $\frac{1}{3309}$ | 40 | 20 | 20 | 20 per cent. >0.01 inch. |
| | | Bottom.. | 559, 500 | ......... | ...... | .... | .... | .... | |

## RIVER SLOPE.

The slope of the water surface was determined for short sections of the river from Scanlon's Landing to Delta, with the exception of a short stretch between Walnut Bend Landing and Austin, or more properly O. K. Landing. The method adopted was to set out gauges from two to six miles apart, the zeros of which were carefully connected by a line of levels, and take simultaneous readings on them for five hours. The difference in height of the water surfaces at the two gauges divided by the distance between them in miles gives the slope or fall per mile.

In cases where it was necessary to get the gauge-readings before the levels were run in order to obtain the slope corresponding to a certain stage of water, the guages were established in the usual way, and their zeros referred to bench-marks on the bank in some secure place, these bench-marks being connected with the levels afterward.

| Locality. | Distance between gauges. | Date. | Stage of river at Memphis. | Rising or falling per hour; + rising, − falling. | Surface slope per mile. | Remarks. |
|---|---|---|---|---|---|---|
| | *Miles.* | 1879. | | *Feet.* | *Feet.* | |
| Scanlon's Landing to Norfolk Landing. | 6. 9 | Jan. 2 | 9. 8 | −0. 035 | 0. 34 | Gauge.—Scanlon's, in still water, straight river. |
| Scanlon's Landing to Norfolk Landing. | 6. 6 | Jan. 26 | 28. 3 | +0. 017 | 0. 42 | Gauge.—Norfolk, in current, straight river. Two gauges near Norfolk. |
| | | 1878. | | | | |
| Norfolk Landing to Star Landing. | 4. 4 | Dec. 6 | 17. 2 | +0. 127 | 0. 35 | Gauge.—Star Landing, in current, straight river. |
| | | 1879. | | | | |
| Norfolk Landing to Star Landing. | 4. 8 | Jan. 28 | 28. 9 | +0. 014 | 0. 36 | |
| | | 1878. | | | | |
| Star Landing to Bennett's Landing. | 5. 3 | Dec. 10 | 20. 7 | −0. 006 | 0. 25 | Gauge.—Bennett's Landing, in current, convex bend. |
| Bennett's Landing to Commerce Landing. | 6. 2 | Dec. 12 | 20. 3 | −0. 010 | 0. 44 | Gauge.—Commerce Landing, in current, convex bend. |
| | | 1878. | | | | |
| Commerce Landing down to No. 2. | 2. 5 | Nov. 30 | 4. 8 | ........ | 0. 415 | Gauge No. 2, at foot of Clarke's towhead, in main current. |
| No. 3 to No. 4.......... | 2. 6 | Dec. 13 | 20. 4 | ........ | 0. 729 | Gauge No. 3, in current in convex bend; No. 4, same, at Mhoon's Landing. |
| No. 4 to No. 5.......... | 3. 3 | Dec. 17 | 21. 1 | ........ | 0. 426 | Gauge No. 5, in current at head of Bordeaux Chute. |
| No. 5 to No. 6.......... | 3. 05 | Dec. 21 | 21. 0 | ........ | 1. 090 | Gauge No. 6, in current at foot of Bordeaux Chute. |
| | | 1879. | | | | |
| △ Star Landing to "O" Gauge No. 1. | 7. 42 | Jan. 29 | 28. 9 | ........ | 0. 380 | Both gauges in current in straight river, "O" 1 2,100 metres below △ Cottonwood. |
| Commerce Landing (No. 1) to No. 10. | 3. 11 | Jan. 29 | 28. 9 | ........ | 0. 724 | No. 10, at foot of bar, Clark's. |

| Locality. | Distance between gauges. | Date. | Stage of river at Memphis. | Surface slope per mile. | Remarks. |
|---|---|---|---|---|---|
| | *Miles.* | 1878. | *Feet.* | *Feet.* | |
| Between (Gauge 1) O. K. Landing and Harbert's Point (Gauge 2). | 2.17 | Nov. 29 | 4.8 | 0.31 | Gauge No. 1.—Just above where current strikes the bank above O. K. Gauge No. 2.—A short distance below where main channel leaves left bank. |
| Between Harbert's Point and Saint Francis Island (Gauge 4). | 6.22 | 1879.<br>Feb. 19 | 20.2 | 0.475 | Gauge No. 4.—Behind a sand point, out of the current, and opposite Saint Francis Bend. |
| Between Saint Francis Island and Helena Island (Gauge 6). | 4.35 | 1878.<br>Dec. 11 | 20.7 | 0.243 | Gauge No. 6.—A little above where current strikes the bend at Helena Island. |
| Between Helena Island and point above Glendale (Gauge 8). | 2.71 | Dec. 18 | 20.9 | 0.610 | Gauge No. 8.—A short distance below where current leaves left bank. |
| Between point above Glendale and bar below (Gauge 10). | 2.92 | Dec. 23 | 20.8 | 0.298 | Gauge No. 10.—Out of current. |
| Between bar below Glendale and Grant's Pass (Gauge 11). | 4.50 | 1879.<br>Jan. 3 | 9.2 | 0.370 | Gauge No. 11.—A short distance above where main current strikes the bank in Montezuma Bend. |
| Between Grant's Pass and Delta (Gauge 13). | 3.11 | Jan. 4 | 8.7 | 0.357 | Gauge No. 13.—A short distance below where current leaves the left bank. |

## APPENDIX No. 4.

### REPORTS OF CHIEFS OF PARTIES.

### 1.—REPORT OF LIEUTENANT P. M. PRICE, CORPS OF ENGINEERS.

DETROIT, MICH., *May* 1, 1879.

SIR: I have the honor to submit the following report of the duties upon which I have been engaged since June 30, 1878:

During the month of July I was in the office. On July 30 I was directed to proceed on August 2 to Sandusky, Ohio, to read the angles at the ends, at the two angular points, and at the auxiliary station of the Cedar Point base line which was then being measured. I used the Pistor and Martin 14-inch theodolite, and obtained twenty-four combined results in each angle. I also read to the steeple of the Methodist Church from the east and west base stations, and connected the steeple with the longitude post of 1868 by azimuths and distances.

The above work was completed, and I returned to Detroit on October 26.

On November 1, I was directed to proceed to Memphis, Tenn., reporting *en route* to Lieutenant Lockwood, at Louisville, Ky., for instructions in regard to the beginning of the survey at Memphis. I was also to remain at Louisville to assist Lieutenant Lockwood in preparing the quarter-boats until the yellow fever had abated sufficiently at Memphis to render it safe to go there. I reached Memphis on November 16, and between that time and the 20th, when Lieutenant Lockwood arrived with the new boats, I had the Arkansas disinfected and cleaned.

During the field season I had charge of the survey-boat Louisiana, the parties on which consisting, besides myself, of Assistant Engineer G. Y. Wisner, Recorders G. W. Carman and C. M. Lightner, and a crew of 14 men, were directed to do the secondary triangulation.

The angles were read by Mr. Wisner and myself, my instrument being the 12-inch Troughton and Simms theodolite.

The *Louisiana* was towed down to Norfolk Landing on the 24th of November.

The triangulation was commenced at the line Fairview—State-Line—the closing line of the preceding season's triangulation, by the occupation of those two stations.

Much time and labor were saved by the use of portable stations, five of which I had made by the crew at the commencement of the season. The tripods—three of which were 12 feet, and two 6 feet, in height—were made of 4 by 4 inch stuff, braced by 2 by 4 inch scantling, and the parts were fastened together by ½-inch bolts, 6½ and 7 inches long, so that they could be readily taken apart and put together again. It was found, however, that it was unnecessary to take the tripods apart in transporting them. One could be readily carried in the six-oared cutter by placing it across the bow. The corner posts of the platforms were 3 by 3 inch scantling, and the braces, 2 by 4 inch scantling, and were put together by bolts in the same manner as the tripods. The platform had to be completely taken apart in moving the station.

The triangulation was continued without interruption, other than that caused by occasional bad weather, until Walnut Bend was reached, on the 2d of January. During the night of the 2d, ice commenced running in the river and continued until the 18th of January, and during this time triangulation was completely suspended, as it was impossible to cross the river to put up targets or stations. Work was resumed on the 18th, but was again interrupted on the 24th, by which time the river had risen to such a height as to overflow its banks in many places and prevent the location of stations and cutting of lines. We were not able to proceed with the triangulation until February 3. On the 8th it had been completed to the mouth of the Saint Francis River, and on the 10th the Louisiana was towed back to Harbert's Point, orders having been received that a base line should be measured by Mr. Wisner and that I should read the angles to connect the base line with the triangulation. I also determined the azimuth of the base line by three nights' observations on Polaris, and two on δ Ursæ Minoris, at their elongations.

The operations at the base line were completed and the triangulation taken up again on the 1st of March, and the last stations were occupied on the 4th of March. The triangulation closed on the line △ Helena Island—at the head of Helena Island—and △ Adams on the Arkansas shore about 2¼ miles above Helena. It is believed that both these stations will remain for several years.

During the season I occupied 32 stations and read 126 angles, obtaining 8 combined results on each angle.

Recorder C. M. Lightner rendered efficient service during the season.

The Louisiana was towed up to Memphis on March 6, and on the following day the property was stored in the warehouse and the crew discharged. I returned to Detroit on the 16th of March, and since that time have been engaged in tabulating the results of the winter's work and in collecting material for a history of the Lake Survey.

Very respectfully, your obedient servant,

PHILIP M. PRICE,
*First Lieutenant of Engineers.*

Maj. C. B. COMSTOCK,
*Corps of Engineers.*

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## 2.—REPORT OF MR. G. Y. WISNER, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE SURVEY,
*Detroit, Mich., April* 30, 1879.

SIR: I have the honor to submit the following report of work done by the party under my charge since September 4, 1878.

In accordance with your instructions of September 4, 1878, the party was organized, with J. C. Eaton as recorder and T. C. Hockridge as observer's attendant, and proceeded at once to Sturgis, Mich., to continue the measurement of angles of the primary triangulation between Lake Erie and Lake Michigan.

The party remained in the field until November 8, and then returned to Detroit for the season.

On November 18, I again left Detroit for field-work and reported to Lieut. D. W. Lockwood, at Memphis, Tenn., for duty on board the United States survey-boat Louisiana, and until March 7, 1879, was occupied, in connection with Lieut. P. M. Price, in reconnoitering and measuring angles for the triangulation of the Mississippi River, and in measuring a base line at Harbert's Point, Miss.

On March 10, I returned to this office, and since then have been occupied with the reduction and compilation of my past season's fieldnotes, reduction of the water-level records for the lakes, and duplicate computation of a portion of the levels of precision for the Mississippi River.

The following table gives a summary of field work:

| | |
|---|---|
| Triangulation between Lake Erie and Lake Michigan: | |
| Number of stations occupied | 7 |
| Number of primary angles measured | 32 |
| Number of vertical angles measured | 27 |
| Mississippi River triangulations: | |
| Number of stations located | 63 |
| Number of stations occupied | 31 |
| Number of angles measured | 118 |
| Number of base lines measured | 1 |

Very respectfully submitted.

GEO. Y. WISNER,
*Assistant Engineer.*

Maj. C. B. COMSTOCK,
*Corps of Engineers, U. S. A.*

### 3.—REPORT OF MR. R. S. WOODWARD, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE SURVEY,
*April* 30, 1879.

SIR: In compliance with your orders of April, 1879, I have the honor to submit the following report of field and office work done by me between July 3, 1878, and May 1, 1879.

On July 3, 1878, I left Detroit with instructions to remeasure the primary angles at stations Oswego, Stony Point, south base, and Gasport, locate a shoal in the Saint Lawrence River near Dickinson's Landing, and inspect the water-gauge stations at Sacket's Harbor, N. Y., Charlotte, N. Y., Erie, Pa., and Cleveland, Ohio.

The work was completed November 25, on which date I returned to Detroit.

In the triangulation, one new line, viz, Oswego, south base, was observed over in both directions, and several new sum-angles were measured. The work at Oswego was delayed and rendered tedious and unsatisfactory by haze, high wind, and lack of refraction on the lines to Vanderlip and Duck stations. It is probable, however, that the ten new sum-angles observed, together with the measurements of 1875, will give a good determination of the angles.

At Stony Point and Gosport stations considerable delay was caused by gales.

Between November 25, 1878, and May 1, 1879, I have been engaged chiefly on the following office work:

1. Tabulation of angles read by me in 1878, with computation and application of corrections for positions of instrument and signals.
2. Tabulation of primary angles read by Assistant Engineer G. Y. Wisner in 1878, with computation and application of corrections for positions of instrument and signals.
3. Computation of adjustment of quadrilateral about Minnesota Point base-line.
4. Reduction of eight nights' time observations made by Capt. H. M. Adams, and two nights' time observations made by Lieut. C. F. Powell, in 1878.

During the past winter, also, the results of observations which have been made since the spring of 1876, for determining the constants of the Troughton and Simms theodolite No. 3, have been collected, and are given in MS. Report No. 1009.

The constants determined are:

1. Value of space on horizontal limb between graduation marks 359° 55′ and 00°.
2. Value 1 division of vertical circle level.
3. Value 1 division of striding level.
4. Constants in terms of periodic series eliminated in mean of the readings of the microscopes on horizontal limb.
5. Constants in terms of periodic series not eliminated in the mean of the readings of the microscopes on horizontal limb.

The following is a summary of the season's field work:

| | |
|---|---|
| Number stations occupied | 4 |
| Number angles measured | 35 |
| Number water-gauge stations inspected | 4 |

Very respectfully,

R. S. WOODWARD,
*Assistant Engineer.*

General C. B. COMSTOCK,
*Superintendent United States Lake Survey.*

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### 4.—REPORT OF MR. J. A. OCKERSON, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE SURVEY, *May* 1, 1879.

SIR: I have the honor to submit the following report of work done by the party under my charge during the winter of 1878–'79 on the survey of the Mississippi River.

I arrived at Memphis, Tenn., on November 20, and on the 21st was assigned quarters on the United States survey-boat Tennessee.

After taking on board the necessary property, the quarter-boat was towed to O. K. Landing, Miss., 60 miles below Memphis. In accordance with instructions from Lieut. D. W. Lockwood, a survey extending from near Austin to Delta, Miss., for the Mississippi River Board of Engineers, was begun on November 28.

This survey, which was in advance of the secondary triangulation, comprised a tertiary triangulation, a duplicate line of levels, determination of river slope, shore line of both banks, of bars, tow-heads, and islands; topography of bars and tow-heads and soundings.

Observations for azimuth were made at O. K. Landing, and the triangulation was carried from a carefully chained base-line to a check base at the end of the work, where observations for azimuth were also made, as a check on previous determinations.

A duplicate line of levels was carried down the left bank of the river. The line was duplicated by using two rods over the same turning points, the height of the instrument being changed for each rod. Between Austin and Trotter's Landing, a distance of about 18 miles, the mean result differed from the precise levels 0.030 foot, being smaller.

At Delta, a distance of 12 miles from Trotter's Landing, the mean result differed from the precise levels 0.124 foot, being smaller.

Gauges to determine river slope were placed at intervals averaging 3.6 miles, the greatest distance being 6.2 and the shortest 2.2 miles.

The elevations of zeros were determined by the ordinary levels, and to determine slope simultaneous readings were taken at two gauges for at least five hours. These readings were taken when the river was nearly stationary, as determinations made when the river is either rising or falling rapidly are necessarily erroneous.

The river slope changes with every change of the stage of the river; therefore these determinations are only true for the stage at which they were made.

The results are given in Table No. 1.

The northwest corner of Township 29 north, range 3 west, was connected with the survey.

At Delta the elevation of the high-water mark of 1874 was determined.

The record was kept by Mr. T. B. Hooker, who marked on a gate-post the highest point reached, which was on April 17.

The elevation of this point above the datum plane = 189.8 feet; on January 11, 1879, water surface was 153.4 feet above datum plane.

### SOUNDINGS.

In sounding, a lead weighing 19¼ pounds was used, as it was found that a light lead, such as was used in sounding on the lakes, did not give good results. A smaller lead-line would be better, as a smaller surface would then be exposed to the action of the current.

Generally, lines were sounded across the river at intervals of from 250 to 500 meters. But where the current was rapid and the water deep, better results were obtained by sounding lines longitudinally, allowing the cutter to float down, the crew rowing just enough to give steerage way. Soundings were located with theodolites from these tertiary points on shore.

The Prairie Point Bar and the bar below Glendale were surveyed twice, at stages differing about 16 feet. There are both soundings and elevations determined by theodolite, covering the same area. On reducing soundings to elevations above datum plane, and comparing with topographic elevations, they were found to agree very closely, showing that in the cases quoted the elevation of the bars was not changed by their being submerged.

### CAVING BANKS.

On the left bank, from the foot of Ship Island down about a mile, the bank is clay and sand, and is caving rapidly.

The right bank opposite Shoo Fly Bar, composed of sand and silt, is said to have caved 400 feet in four years. The soil does not break away in large masses, as in the case of clay banks, but crumbles in and washes away, much as though it was fine dry sand.

Near the mouth of the Saint Francis River the right bank is caving slightly.

The next caving is at Helena Island, and extends along the left bank to three-fourths of a mile below Trotter's Landing. The island is composed of very loose soil, which wears away easily.

At Trotter's Landing the bank is clay and sand, and during the time the party was working in that vicinity, caving was going on at the rate of 10 feet per day.

In the bend below Helena the banks are silt and sand, and caving.

In Montezuma Bend the banks are silt with streaks of blue clay overlying sand, and cave rapidly, entire plantations having disappeared. The process here seems to be that the sand washes out underneath, and the firmer soil composing the upper strata settles with the river bodily, often leaving the trees erect for some time. In this way several acres disappear at the same time. When the ground begins to settle, the process is hastened by the rain which flows into the seam behind it. After it once becomes submerged it wears away quite rapidly.

### BARS AND TOW-HEADS.

The middle bars between O. K. and Harbert's Landings are chiefly sand, except at the lower end, where silt is found. Opposite these bars, on the right bank, is a sand bar extending down about a mile below Harbert's Landing. There is no gravel on either of these bars. The sand is divided about as follows, viz: 45 per cent. less than 0.01 inch, 40 per cent. between 0.01 and 0.02 inch, and 15 per cent. above 0.02 inch in diameter.

Shoo Fly Bar lies about a mile below Harbert's Landing. The head of the bar is mostly gravel, varying from 0.1 inch to 4.0 inches in diameter.

The main part of the bar is sand, of which 40 per cent. is less than 0.02 inch in diameter, 40 per cent. between 0.02 inch and 0.04 inch, and 20 per cent. above 0.04 inch. At the lower end is a narrow strip of silt.

The only information in regard to the movement of this bar downstream was obtained from a pilot, and a negro who had lived near it four years. The former said it was moving down stream rapidly, but could not tell how fast. The latter said it had moved down nearly half a mile in four years.

The point bar on the left bank opposite is of the same character as Shoo Fly Bar, except that the gravel found at its head is smaller.

Saint Francis tow-head is chiefly silt, and is covered with a dense growth of cottonwood. A bar extends down from the lower end, and the upper end is wearing away rapidly.

The Prairie Point Bar is sand with a little fine gravel, the latter being less than 0.2 inch in diameter. Twenty per cent. of the sand is less than 0.005 inch in diameter, 50 per cent. between 0.005 inch and 0.01 inch, 20 per cent. between 0.01 inch and 0.02 inch, and 10 per cent. more than 0.02 inch.

Helena tow-head is chiefly sand of the same character as the bar, except near the lower end, where silt predominates. It is covered with a heavy growth of willows and cottonwood.

The bar on left bank extending from near Glendale to Grant's Pass is mostly sand, except at the lower end, which expands into a mud flat covered with small willows. A narrow strip of gravel extends along the upper portion of the bar. It varies in size from 0.1 inch to 4 inches in diameter. The sand along the higher portions of the bar has 75 per cent. less than 0.005 inch in diameter, 15 per cent. between 0.005 inch and 0.01 inch, and 10 per cent. above 0.01 inch.

Montezuma Bar is chiefly sand, except at the head, where considerable gravel is found. There is also a narrow strip of gravel on the right bank, near the foot of the bar.

It varies from ¾ inch down to coarse sand. A specimen of sand taken at low-water gives 10 per cent. less than 0.01 inch, 30 per cent. between 0.01 inch and 0.02 inch, and 60 per cent. between 0.02 inch and 0.05 inch in diameter. It was generally observed that the finer sand was found on the high parts of the bar, growing gradually coarser toward the lower portions. This indicates that specimens obtained where only a small part of the bar was exposed would not fairly represent the character of them.

The survey between O. K. Landing and Delta was completed, with the exception of one day's soundings, on January 3, when the ice began to run and prevented further work till January 18. The amount of work done is given in detail in Table No. 2.

### TOPOGRAPHY.

On the arrival of the Little Eagle, the quarter-boat was towed up to Excelsior Landing, Ark., which point was reached on January 24, and topographical work was begun on the following day.

The river was so high by this time that the banks were overflowed in many places, and the swamps and the low ground back filled up to such an extent as to seriously retard the work. In some cases it became necessary, in cutting out section lines, for the axemen to work in water waist deep, though it was often so cold that ice would form during the night.

In the vicinity of Excelsior Landing the land is covered with a heavy growth of cane, vines, and woods, which made it necessary to do a great deal of chopping, and four extra axemen were employed for six days.

A stone line was established one and a quarter miles below Bennett's Landing. Four stones, two on each side, are placed on a line which is nearly at right angles to the direction of the river, and passes through secondary station cottonwood.

The stones nearest the bank are about a half a mile back, and the others one and a half miles back, from the river. They are carefully connected with the secondary triangulation, and their elevations are determined by duplicate levels.

On this section many of the secondary stations had been washed out, and it became necessary to supply their places by tertiary points.

The high water left so little of the banks exposed that no determination of their character was made, except to note whether they were caving or otherwise. Nearly opposite Commerce the caving on the right bank amounted to 300 feet or more in a month. When topographical work was begun at Excelsior Landing the elevation of 37 feet mark on gauge on Bennett's Landing, as given in report of F. W. Lehnartz, 1878, was used.

Afterward the levels were connected with reference points 68 and 70, precise levels, which showed that the elevation of 37 feet mark as given was 0.632 feet too high. As the benchmark established at Bennett's Landing at the time the gauge was set could not be found, it was not determined whether the post on which the 37-foot mark was placed had settled, or whether an error was made in the precise levels between the main line of precise levels and the water-gauge.

Considerable difficulty was experienced in finding the reference points left by the precise levels. These usually consist of spikes driven into trees. The wood grows so rapidly that, although less than a year had elapsed since the spikes were driven, some of them were found to be covered to a depth of two inches.

In order to show the slope of the land from the river bank back, eight sections on the Arkansas side and six on the Mississippi side have been plotted and are appended herewith. These sections are a mile or more apart, and are taken nearly at right angles to the river. Narrow depressions, like bayous, &c., were not plotted. The line of average slope was put in by inspection after plotting its center of gravity from the mean ordinate and abscissa.

In addition to the regular topographical work, daily observations for sediment were made. The sections at Trotter's Landing and Glendale were also sounded twice.

The results of the sediment observations are given by Lieutenant Lockwood in his report.

On March 7 the quarter-boat was taken to Memphis, where the property was stored and the party discharged.

The amount of work done is given in table No. 3.

Since the close of the field season I have been engaged in reducing field notes and mapping.

I am indebted to Recorders B. H. Colby, H. C. Gould, and W. M. Childs for valuable assistance in the field.

Very respectfully, your obedient servant.

J. A. OCKERSON,
*Assistant Engineer.*

Maj. C. B. COMSTOCK,
*Corps of Engineers, U. S. A.*

TABLE I.—*River slope between O. K. Landing and Delta, Miss.*

| Locality. | Date. | Distance between gauges. | Stage of river at Memphis. | Rise or fall per hour. | Slope per mile. | Remarks. |
|---|---|---|---|---|---|---|
| | | *Miles.* | *Feet.* | *Feet.* | *Feet.* | |
| Between O. K. and Harbert's Landings. | 1878.<br>Nov. 29 | 2.17 | 4.7 | +0.01 | 0.31 | 1st gauge is just above where current strikes bank; 2d gauge, a short distance below where main channel leaves left bank. |
| Between Harbert's and Saint Francis Island. | 1879.<br>Feb. 19 | 6.22 | 20.2 | −0.06 | 0.475 | 4th gauge, behind a sand point, out of the current, and opposite Saint Francis tow-head and bend. |
| Between Saint Francis Island and Helena Island. | 1878.<br>Dec. 11 | 4.35 | 20.6 | 0.000 | 0.243 | 6th gauge, a little above where current strikes bend at Helena Island. |
| Between Helena Island and Glendale. | Dec. 18 | 2.71 | 20.8 | −0.005 | 0.610 | 8th gauge, a short distance below where current leaves left bank. |
| Between near Glendale to bar below. | Dec. 23 | 2.92 | 20.7 | +0.003 | 0.298 | 10th gauge, out of current at head of bar. |
| Between bar below Glendale and Grant's Pass. | 1879.<br>Jan. 3 | 4.50 | 9.2 | −0.04 | 0.370 | 11th gauge, a short distance above where current strikes Montezuma Bend. |
| Between Grant's Pass and Delta, Miss. | Jan. 4 | 3.11 | 8.6 | −0.036 | 0.357 | 12th gauge, a short distance below where current leaves left bank. |

TABLE 2.—*Showing work done between O. K. Landing and Delta, Mississippi.*

| | |
|---|---|
| Number of base-lines measured | 3 |
| Number of observations for azimuth | 5 |
| Number of tertiary stations built and occupied | 65 |
| Number of water-gauges established | 17 |
| Number of level readings | 1,492 |
| Number of theodolite pointings | 9,536 |
| Number of theodolite readings | 15,571 |
| Number of miles of shore line | 105.5 |
| Number of square miles of topography | 9.3 |
| Number of miles of levels in duplicate | 28 |
| Number of casts of lead | 3,711 |
| Number of miles of river surveyed (measured along channel) | 25.3 |

TABLE 3.—*Showing amount of work done from Bennett's Landing down.*

| | |
|---|---|
| Number of level readings | 2,343 |
| Number of vernier readings | 10,226 |
| Number of theodolite pointings | 5,750 |
| Number of miles of shore line | 26.6 |
| Number of square miles of topography | 22.5 |
| Number of miles leveled | 54 |
| Number of miles chained | 8 |
| Number of miles of river surveyed (measured along channel) | 9.6 |
| Number of tertiary stations occupied | 5 |

*Summary of work done during season of* 1878-'79.

| | |
|---|---|
| Number of base-lines measured | 3 |
| Number of observations for azimuth | 5 |
| Number of tertiary stations built and occupied | 70 |
| Number of water-gauges established | 17 |
| Number of level readings | 3,835 |
| Number of vernier readings | 25,797 |
| Number of theodolite pointings | 15,286 |
| Number of miles of shore line | 132.1 |
| Number of square miles of topography | 31.8 |
| Number of miles of levels | 110 |
| Number of miles chained | 8 |
| Number of casts of lead | 3,711 |
| Number of miles of river surveyed | 34.9 |

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## 5.—REPORT OF MR. JOHN EISENMANN, ASSISTANT ENGINEER.

UNITED STATES LAKE SURVEY OFFICE,
*Detroit, May* 31, 1879.

SIR: I have the honor to make the following report of the work accomplished under my charge on the survey of the Mississippi River during the present fiscal year:

1. I was placed in charge of the survey boat Arkansas on November 21, 1878, at Memphis, Tenn., with a force of 3 assistants and 20 men.

After the making up of the outfit was completed, Lieut. D. W. Lockwood, Corps of Engineers, took the party down the river, on the 24th, and left it at the head of Commerce Cut-off, with instructions to begin the hydrography and continue it down toward Austin. The limit was afterward fixed at Walnut Bend P. O., Lee County, Arkansas.

This work was divided into three sections.

*The first*, reaching from Commerce Landing, Miss., to within 2¼ miles of Mhoon's Landing, Miss., being a distance of 5 miles. It was finished by December 5, and is the only portion done at very low water.

*The second* extended from the lower limit of the first to within 1 mile of the head of Bordeaux Chute, being a distance of 5 miles, which was completed on December 16.

*The third* extended from the lower limit of section 2, through Bordeaux Chute to Walnut Bend P. O., Ark., a distance of 5 miles, which was completed by December 23.

In doing the above hydrographical work the new channel of the river was followed, and, aside from the ordinary soundings, it comprised river-slope determinations, the development of all sand bars by stadia, a line of ordinary levels, a system of tertiary triangles, and four nights of azimuth observations.

There were fifty lines sounded, the soundings of which were located by three theodolite intersections.

The results obtained for river slope have already been reported upon by Lieutenant Lockwood.

The line of ordinary levels was run down on the Mississippi side of the river, for connecting the zeros of water-gauges and their bench-marks with the precise level bench-marks at Commerce and Mhoon's.

The system of tertiary triangles, adopted in advance of the secondary triangulation for the connection of the various points of reference, is dependent upon a chained base at Commerce Cut-off, and a check base, chained at the foot of Bordeaux Chute. The system was afterward connected with by the secondary triangulation parties.

Two nights of azimuth observations were taken at Commerce Landing on δ Ursæ Minoris at western elongation, and two observations were taken at the head of Bordeaux Chute on α Ursæ Minoris at western elongation.

### 2. TOPOGRAPHY.

On December 24, 1878, the Arkansas was taken up the river and left at Harckelrode's Landing, Crittenden County, Arkansas, with instructions from Lieutenant Lockwood to begin the topographical survey at this point.

The upper limit of the topography is stone line No. 10, whose general azimuth is 296° 20′, which starts at bench-mark $\frac{10}{7}$, 250 meters from the northeast shore of Horse Shoe Lake, and 3.33 miles from the west bank of the river, and ends at bench-mark $\frac{10}{8}$, 1½ miles from its eastern bank. The line crosses the river at about ½ a mile above Star Landing, De Soto County, Mississippi.

From January 1, 1879, to January 24, the work was almost exclusively confined to the west side of the river, on account of the floating ice and the unusual severity of the weather.

The area completed by January 24 extended from stone line No. 10 to Porter Lake Bayou, and 4½ miles back from the river. It embraces Horse Shoe and Goose Lakes, the surveys of which were made on the ice.

On January 25 the Arkansas was taken across to the Mississippi side and tied up, ¾ miles below Star Landing. The area surveyed from this point was 1½ miles wide, and extended from stone-line No. 10 to secondary station Buck Island Chute. It was completed by February 6, and on February 7 the Arkansas was dropped down as far as Hackler's plantation, nearly opposite Bennett's Landing, Mississippi. From this point the work was extended, with a width of 1½ miles, down on both sides of the river, to the secondary line, Bennett-Hackler, the upper limit of Assistant Engineer J. A. Ockerson's work. It included Porter Lake and the remainder of Porter Lake Bayou, on the west side, and Old Buck Island on the east side.

Lines of ordinary levels, starting from the precise bench-mark at Star Landing, were run down both banks of the river, and checked on the precise reference-points at Bennett's Landing. River crossings were made at Star Landing, Buck Island Chute, and Bennett's Landing.

A rapid triangulation was made of Horse Shoe and Porter Lakes. The ends of the stone-line and of field sheets on the river front were connected by triangles to the secondary triangulation.

Observations for magnetic variation were taken at the secondary stations Horseshoe Lake, Buck Island, Bennett's, Hackler, and Porter Lake, and at several intermediate points.

3. The above work having been completed on February 17, Lieutenant Lockwood on the 18th moved me into the old river, at Council Bend.

A system of tertiary triangulation, based upon the secondary line, Commerce-Peter's, was at once projected. It passes around Council Bend a distance of 15 miles, in 27 triangles, and returns to the same base. There were 15 lines sounded.

All the shore-line and topography of Linwood Point, and on the main land from Peter's Landing, about one mile in width to Bledsoe's, was taken.

A line of ordinary levels was carried from Blue's Point across to Linwood Point, and from there to Old Basket Landing, and thence down to Peter's Landing, and also up to Bledsoe's, where the connection with Assistant Engineer Ockerson's work was made.

The work in Council Bend was finished on March 9, and on the 10th Lieutenant Lockwood took the Arkansas up to Memphis. The property was stored and the party disbanded by the 11th.

I left Memphis, on the evening of the 11th, for Cairo, Ill., with instructions to make the connection between the United States Mississippi River triangulation and the United States Coast Survey's astronomical post at that place.

The connection was made by the 13th, and on March 15 I reported for office duty in Detroit.

I am much indebted to Messrs. William Voigt and J. B. Johnson for their hearty co-operation and valuable assistance rendered throughout the entire field season, and also to Mr. George A. Toole, who faithfully performed a recorder's duty after January 20, on which day Assistant Engineer F. A. Fisher was relieved.

4. I herewith append results obtained during the field season.

### *a. Triangulation.*

| | |
|---|---|
| Commerce base of 420.86 meters, worked through 46 triangles, gave the length of Bordeaux base | 562.15 |
| Bordeaux base, chained length | 562.17 |

| | | Azimuth. | Distance. |
|---|---|---|---|
| At Commerce: | | | |
| Tertiary line △ 4–△ 6 | = | *358° 44′ 11″.1 | 1080.99 |
| Same from secondary | = | 358° 44′ 04″.1 | 1081.09 |
| After passing around Council Bend | = | 358° 43′ 56″.7 | 1080.91 |
| At Bordeaux Chute: | | | |
| Tertiary line △ 37–△ 38 | = | *146° 18′ 48″.3 | 1458.50 |
| Same from secondary | = | 146° 19′ 21″.5 | 1458.60 |
| From Bordeaux observations | = | 146° 17′ 51″.8 | 1458.55 |

### *b. Ordinary levels.*

| | Distance. | Discrepancy. |
|---|---|---|
| Commerce P. B. M. to Mhoon's P. B. M | 8 miles | 0. 10 feet. |
| Star Landing P. B. M. to Bennett's P. R. P. 65 | 7 “ | 0.004 “ |
| Star Landing P. B. M. to Bennett's water-gauge | 6 “ | 0. 06 “ |
| Blue's Point, including two river crossings, to Bledsoe's | 10 “ | 0.224 “ |

### *c. Topography.*

Aside from the methods given in your instructions to chief of parties, the following was adopted:

In a wooded country care was taken in ranging the cutting of the necessary section and cross lines. The general azimuth of a line at its ends was taken by a theodolite, and the contours and distance were found by the level. A self-reading rod and a pair of stadia wires gave the level and the wire interval for the distance in the same observation.

A table of wire intervals and their corresponding distances was made from 10 sets of whole and 20 sets of half interval observations.

After each day's adjustment the intervals were checked, and its correction, if any, applied to the table.

As in leveling the rod is rarely over 200 meters from the instrument, the wire interval could be determined to tenths of meters.

A reduction of part of the work shows that it was done with results far within the ordinary stadia limits.

Previously, the level was sent over a line for contours only, its distance being found afterward by chain or stadia. By the above method one-half the labor was saved.

5. The following table gives the work in detail:

| | |
|---|---|
| Tertiary triangulation, stations built | 118 |
| Triangulation stations, secondary and tertiary, located | 151 |
| Sounding stations built and located | 36 |
| Azimuths observed | 4 |
| Bases chained | 5 |
| Theodolite pointings | 12,975 |
| Theodolite readings | 19,374 |
| Vertical angles | 5,075 |
| Lines sounded | 83 |
| Casts of lead | 2,179 |
| Distance leveled in kilometers | 153 |
| River crossings | 8 |
| Bench-marks set | 28 |
| Bench-marks set on stone-line No. 10 | 5 |
| Water-gauges set | 24 |
| Water-gauge readings | 681 |

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* Allowance for convergence was made.

| | |
|---|---|
| Hydrograpy, in miles along river channel, old and new | 30 |
| Hydrography in miles, inland lakes | 9 |
| Shore-line in miles, river | 29 |
| Shore-line, in miles, inland lakes | 24 |
| Topography, in miles, of river length | 14 |
| Topography, in square miles | 47 |
| Sand bars surveyed, number of | 8 |

6. Since returning to the office, the final reduction and computation of the season's work was made, and with the assistance of Assistant Engineer William Voigt the final office charts are being drawn.

Very respectfully, your obedient servant,

JOHN EISENMANN,
*Assistant Engineer.*

Maj. C. B. COMSTOCK,
*Corps o Engineers, Brevet Brigadier-General, U. S. A.*

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## 6.—REPORT OF MR. J. H. DARLING, ASSISTANT ENGINEER.

DETROIT, *April* 30, 1879.

SIR: I herewith respectfully submit a report of work done by the party under my charge during the winter of 1878-'79 on the Mississippi River survey.

I commenced operations November 24, 1878, near Scanlon's Landing, about 17 miles below Memphis, having with me Assistant Engineer C. M. Winchell, Recorders J. A. Paige and J. C. Eaton, and 21 men.

The party was quartered on the United States survey-boat Mississippi, which was kept tied up to the bank in the vicinity of our work, and dropped down stream with the current as the work progressed.

We first sounded the channel from Scanlon's Landing to Commerce Landing, a distance of 22 miles. A six-oared cutter was used for this purpose, and a 10-pound lead, having tallow in a receptacle at the lower end, for determining the character of the bottom of the river. The soundings were made in lines across the river as nearly perpendicular to the channel as possible, these lines being about $500^{\mathrm{m}}$ apart, and the soundings on these lines from $20^{\mathrm{m}}$ to $50^{\mathrm{m}}$ apart. Where the depth was less than 18 feet the lead was cast at every even quarter-minute, and in greater depths at every even half-minute.

In order to locate these soundings, as well as to furnish fixed points for subsequent topographical work, a system of tertiary triangulation was carried on simultaneously with the sounding, and a few miles in advance of it. The triangulation stations consisted of round posts, about 1 foot in diameter, set firmly in the ground and whitewashed. They were marked with red chalk thus, △ 13 D. Angles were read with Würdeman and Stackpole theodolites, closing the triangles with errors of less than one minute. A secondary line near Scanlon's Landing was used for a base in starting, and about 9 miles farther on connection was made with another secondary line, showing a discrepancy of 1:9000. Starting again with this new secondary line, and proceeding about 8 miles farther, a base was chained, whose measured and computed values differed by 1:4000. Starting again with the measured length of this base, the triangulation was continued about 6 miles, until it joined with a triangle side of Assistant Eisenmann's, near Commerce Landing, with a discrepancy of 1:9000. For the last 10 miles or so this tertiary triangulation was in advance of the secondary triangulation.

Soundings were located by three observers with theodolites, who took such tertiary stations for their positions as would give good intersections. A field plot was made of the soundings, scale 1:10000. In plotting, the two pointings were used which gave the best intersections, while the third pointing furnished a check on the other two and also served to supply omissions of either of the other two observers. Sand-bars which were exposed above the water while the sounding was in progress were developed by the stadia.

Observations for river slope were also made during this time, the gauges being connected with temporary bench-marks, whose elevations were determined afterward; and daily gauge readings were made for reducing soundings and shore-line.

The foregoing work was completed December 17, 1878, and, after a delay of one week in getting moved up the river, topographical work was commenced December 26, near Scanlon's Landing, where the previous season's work ended. Had no difficulty in connecting with the old work from marks still remaining.

On January 3, about a week after beginning topography, ice commenced running and caused serious trouble. Not apprehending any danger from this cause, we had tied our quarter-boat to the bank at a point most convenient for our work, and at this time the position was considerably exposed to the moving ice. We protected the boat as much as possible by lining the outer side at water's edge with boards and placing booms of logs in front and alongside. Not having means of fastening these booms securely, they were repeatedly carried away and replaced again. During the first 12 days during which the ice was running the boat escaped serious injury, but after this time the cakes of floating ice were of much larger size, some of them several hundred feet across and 5 inches thick; and on the morning of January 15 the side of the boat was crushed in and she filled and sank in a few minutes. Being close up against the bank, however, one side remained above water and we were able to save nearly all the property.

There was much less ice running on the following day, when the steamer Little Eagle came to our relief and attempted to raise the boat. After two days' effort without success the attempt was abandoned and my party was obliged to resort to tents. We started camp near Norfolk Landing, Mississippi, January 26, and continued the survey. This was extended back from the river to a distance varying from 2,400$^{m}$ (where the river bank was rapidly wearing away) to 1,400$^{m}$ where the bank was more permanent. This survey carefully included all the usual topographical features determining contour lines, 5 feet apart, vertically. Cross-section lines were cut through the wooded country, about 500$^{m}$ apart, extending back from the river to the limit of topography, in order to develop the contour.

Ordinary levels were run along each bank, starting from bench-marks near Scanlon's Landing, established by the previous year's survey, and closing on the Precise Benchmark at Star Landing, leaving "turning-points" about 600 feet apart, whose elevations were recorded, and which served as initial points for the levels run by the stadias for determining contours.

The line of ordinary levels, starting from secondary station Scanlon, and running along the right bank, crossed the river near Star Landing, and closed on the precise bench-mark, Star Landing, with a discrepancy of 0.033 feet, the distance run being 11 miles. On the left bank were found remaining occasional turning-points of a line of levels run the previous season by Assistant Ockerson. These were made use of, their elevations being known.

In leveling across the river at Norfolk Landing and Star Landing, the method of simultaneous observations with two instruments on opposite banks was employed with satisfactory results.

Determination of surface-slope of river by means of simultaneous hourly readings for 5 consecutive hours, on gauges stationed from 5 to 6 miles apart, were made for the whole distance of 22 miles covered by my soundings.

I established stone line No. 9 in the vicinity of Norfolk Landing, consisting of four stone posts, two on each side of the river, at distances of about ¼ mile and 1¼ miles from bank, respectively, and placed so that the four stones form near a right line. The elevations of the tops of these stones were obtained by duplicate levels, and their positions carefully determined by connection with the secondary triangulation.

All elevations of bench-marks, contours, water-surface, and zeros of gauges are expressed in feet, and referred to the adopted datum plane for the vicinity of Memphis.

Observations for magnetic-needle variation were made in the vicinity of Norfolk Landing, Miss., in February, 1879, using four different needles for this purpose, whose results were given weight according to the qualities of the needles.

Connection was made with the land-survey section corner lying between sections 7, 8, 17, and 18, of township 4 north, of range 8 east, Crittenden County, Arkansas; also with several United States Coast-Survey triangulation stations.

The country being for the most part heavily wooded, I found it expedient about the middle of January to increase the number of axmen for cutting cross-section lines, and employed seven new men. My force was still further increased February 8 by Assistant Engineer L. L. Wheeler and his party, who were then assigned to duty under me. Shortly afterwards, however, I discharged a large number of axmen on reaching more open country, and by the 28th of February had brought my work to connect with that of Assistant Engineer Eisenmann, near Star Landing.

I broke camp February 28, 1879, and, after storing property in Memphis, returned to Detroit.

My thanks are due to the assistants and recorders connected with my party; Assistant Winchell's services were especially valuable on account of his long experience and the rapidity and accuracy of his work.

Very respectfully,

J. H. DARLING,
*Assistant Engineer.*

General C. B. COMSTOCK.

## 7.—REPORT OF MR. A. R. FLINT, ASSISTANT ENGINEER.

OFFICE OF UNITED STATES LAKE SURVEY,
*Detroit, Mich., May* 31, 1879.

GENERAL: I have the honor to submit the following report on work accomplished by the computing division since May 31, 1878:

The computing-room was under the charge of Assistant Engineer O. B. Wheeler until July 1, and the work done during the month of June was directed by him. Since July 1 the computing-room has been under my charge.

### ADJUSTMENT OF TRIANGULATION.

The section of the Lake Erie primary triangulation from line Chester-Willoughby to line Cedar Point-Stony Point, closed the previous year with the formation of the normal equations, 50 in number. These equations have been solved and the final corrected angles tabulated.

A section of the Lake Michigan primary triangulation extending from line Fremont-Deerfield to line Bald Tom-Michigan City, including the summit base connection with the primary triangulation, has been commenced, the normal equations, thirty-one in number, have been formed, and at the present time the solution of these equations is about one-fourth completed.

### SECONDARY TRIANGULATION.

The secondary triangulation of the Mississippi River, from Scanlan's Landing, Arkansas, to Helena Island, has been reduced, and the latitudes and longitudes of the stations and azimuths of lines computed geodetically from the Memphis astronomical post. Tables, in triplicate, giving lengths of lines, azimuths, and occasional latitudes and longitudes, were prepared for the field parties as fast as the notes were received from the triangulation parties.

### CHARTS.

For the final chart of Lake Erie, the stations west of Vermilion, including all of the islands and the Canadian shore from Pointe Pelée to the Detroit River, have been referred to meridians and parallels 30′ apart. Tables of water-levels, light-houses, magnetic variation, sailing directions, &c., have been prepared.

For the seven coast charts of Lake Erie, the stations have been referred to meridians and parallels 5′ apart, except for a part of No. 1, which were reduced during the previous year.

Titles and notes have been prepared for these charts and for coast charts Nos. 4 and 5 of Lake Ontario.

The secondary stations on the Mississippi River have been referred to meridians and parallels 1′ apart.

For the index chart of the Northern and Northwestern lakes and connecting rivers, the points selected, usually light-houses, were referred to meridians and parallels 1° apart, and a list of all astronomical and magnetic stations prepared for it.

### ASTRONOMICAL.

The latitude and longitude observations made at Detroit, Mich.; Rock Island, Ill., Red Wing, Minn., and Louisiana, Mo., by Lieut. C. F. Powell, have been reduced, and the results tabulated for publication, including tables of time-work for the Detroit observatory, reduced by Capt. H. M. Adams.

The latitude of Saint Ignace station, from the observations made on the several posts on the island, has been redetermined, using only the results from single pairs of stars.

The latitude of north base station, Minnesota Point, has been rereduced in a similar manner.

The results for longitude of the Lake Survey Observatory at Detroit have been compiled from the several connections made with the United States Naval Observatory at Washington.

The observations made at Harbert's Point, Miss., for azimuth of secondary base, have been reduced and the results tabulated.

### MISCELLANEOUS WORK.

Examined and checked two engraved, three photolithographed, and six original charts, scale $\frac{1}{80000}$; proof-read printed copy of annual report for 1877–'78 and compared it with the original copy on file in the office. Numerous special computations have been made that have arisen in the ordinary course of office work.

Observations for determining the boiling and freezing points of standard thermometers, and also for calibration, have been reduced.

The water-level records from the ten observing stations on the lakes have been reduced by months and the annual curves plotted. A special report has been made on this subject.

All computations not self-checking have been made in duplicate.

Assistant Engineer Kummell has been in the computing room during the year. Assistant Engineer Wright was assigned to this division until July 22, when he was succeeded by Assistant Engineer Russell, who has remained during the year.

Assistant Engineer L. L. Wheeler has been under my direction since returning from field duty, March 1, 1879.

Mr. Russell, in addition to his other duties, has had the care of the chronometer-room, and has observed for time once or twice a month when the regular observatory work was not being carried on. He has also been engaged several weeks in making thermometer observations and comparisons under your immediate supervision. This work has been reduced; a small portion of it only remains to be duplicated.

Respecifully submitted.

A. R. FLINT,
*Assistant Engineer.*

General C. B. COMSTOCK.

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## APPENDIX No. 5.

### MEASUREMENT OF SANDUSKY BASE LINE.

### REPORT OF MR. E. S. WHEELER, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE SURVEY,
*Detroit, June* 9, 1879.

SIR: I have the honor to submit the following report of the measurement of the Sandusky base line.

I received your orders to measure the Sandusky base July 20, 1878.

The organization of the party was as follows: Assistant engineers, E. S. Wheeler, T. W. Wright, and J. Eisenmann; recorders, J. B. Johnson and F. B. Martin; foreman, F. McGillicuddy; a cook, steward, and 12 laborers.

Mr. Martin left the party August 7, and his place was supplied by Recorder B. H. Colby.

The party, instruments, and camp equipage left Detroit on July 25, 1878, on the steamer Jay Cooke, and got into camp the same day on Cedar Point, opposite Sandusky.

The line runs along the outer shore of Cedar Point. The soil is clear sand. The shore is slightly concave, so that the line is a broken one, being divided into three nearly equal parts, whose azimuths differ about 2°.

The ends of the line and the sections were marked in the same way as those of the Chicago base, described on page 1402 Report of Chief of Engineers for 1878.

The line was divided into six sections. The second and fourth section stones were the points where the line changed its azimuth (about 2° in each case).

The angles at these two section stones were measured by Lieut. P. M. Price with a primary triangulation instrument.

The alignment between section stones was accomplished by placing a theodolite midway between them and approximately on line, measuring the angle and computing the distance to the line. This part of the work was assigned to Assistant Engineer Eisenmann.

The adjustments of the apparatus, the making of cuts off, the order of work, and the form of keeping notes were in all respects the same as at the Chicago base, described in report of Chief of Engineers for 1878, pages 1402-1405.

The party was detailed as follows: J. Eisenmann placed the microscopes in position, T. W. Wright observed at rear end, and E. S. Wheeler observed at the forward end of the tube. B. H. Colby recorded at the rear end and J. B. Johnson recorded at the forward end.

General Comstock arrived in camp August 5, and directed the first day's measurement.

The first measurement was completed September 16. The measurement (made in opposite direction) was completed October 12.

Measuring was done on 36 days. The average number of tubes measured per day, including the remeasurements each morning, was 88.

The second measurement of the base was made at the average rate of 100 tubes per day. The greatest number of tubes measured in a single day was 152.

A profile of the base and its mean height above Lake Erie was determined. The party returned to Detroit October 16, having been absent 84 days.

Thanks are due to both assistants and recorders for the skill and care with which they did their work.

Very respectfully,

E. S. WHEELER,
*Assistant Engineer.*

General C. B. COMSTOCK,
*Superintendent Survey of Northern and Northwestern Lakes.*

## APPENDIX No. 6.

### LEVELS OF PRECISION NEAR HELENA, ARK.

#### REPORT OF MR. L. L. WHEELER, ASSISTANT ENGINEER.

DETROIT, *May* 29, 1879.

SIR: I have the honor to make the following report on the levels of precision for the season of 1878-'79 in connection with the survey of the Mississippi River:

I reported for duty on the Mississippi River survey at Memphis, Tenn., November 20, and commenced work at Austin, Miss., November 27, 1878.

My party consisted of Mr. E. S. Davis, recorder, 1 cook, 2 rodmen, and 2 axmen. Quarters were furnished the party on board the United States survey-boat Pioneer.

Kern leveling instrument No. 2 was used until December 23, when, the parts composing the object-glass of the telescope having become separated, No. 1 was substituted in its place.

Level-tube No. 10 (1 division $=3''.05$) was used with both instruments. Kern leveling rods Nos. 2 and 3 were used, the value of the meters of which had been found by comparison with standard meter to be $999.840^{mm}$ and $999.903^{mm}$ respectively. On both rods the graduations commence near the bottom of the rod.

All lines were leveled in duplicate and in opposite directions, it having been shown, by actual levelings, that levelings in opposite directions gave different results. When using two rods, both were used on the same line, rod No. 2 being used for the 1st, 3d, 5th, &c., backsight, and for the 2d, 4th, 6th, &c., foresight, and rod No. 3 for the 2d, 4th, 6th, &c., backsight, and for the 1st, 3d, 5th, &c., foresight, and always using rod No. 2 on the closing bench-mark. Excepting the manner of using the rods, the method of leveling was the same as that described in the Annual Report of the Chief of Engineers for 1877. (Appendix L L.)

In this work care has been taken—

1. That the instruments and rods should be set up as firmly as the nature of the ground would permit.
2. That the errors of adjustment should be small and well determined.
3. That corresponding backsights and foresights should be nearly equal in length.
4. That the sum of the lengths of the backsights and foresights preceding any point on the line should not differ by more than ten meters.
5. That the sum of the level corrections at any point on the line should be small; and,
6. That the time between a backsight and corresponding foresight should be as small as possible, and not exceed 5 minutes. Under favorable circumstances this time would not exceed 1 minute.

The accompanying table contains the result of the season's work. The first column contains the distances between bench-marks. The second column gives the bench-marks and reference points. The third and fourth columns contain the differences of elevation of successive bench-marks, the former for the forward levels, and the latter for the backward levels. The fifth column contains the means of these differences of elevation. The sixth column contains the resulting elevations referred to the datum plane, which is 225 feet (68.5794 meters) below high water of 1858, which read 34.16 feet on the United States engineer's gauge at Memphis, Tenn. The seventh contains the difference in millimeters of the two results between two bench-marks. This result is called positive, when the backward levels give a greater elevation than the forward levels. The eighth column contains the sums of the partial discrepancies.

On commencing work at the bench-marks at Austin, it was found that their difference of elevation had changed 4.4 millimeters since it was determined by Assistant Engineer Lehnartz. It was assumed that their mean elevation had remained unchanged, and the elevations given in the table are based on this assumption.

From Austin to Trotter's Landing the levels were carried along the levee from Trotter's Landing to Glendale along wagon road, from Glendale to reference point 17 along an old levee, and from reference point 17 to Friar's Point along the levee, the total distance being 27.3 miles. From Glendale levels were transferred across the river to Helena, Ark., and connected with the water-gauge and two permanent bench-marks established by my party. The elevation of the 29.5-foot mark of the guage is 54.3744 meters.

The bench-marks at Friar's Point were reached February 5, 1879. Recorder E. S. Davis was then transferred to Assistant Engineer Wisner's party, and myself and party placed under the direction of Assistent Engineer Darling, and by him discharged February 23, 1879.

A list of permanent bench-marks established by my party, with their descriptions and elevations, is appended herewith.

Very respectfully, your obedient servant,

L. L. WHEELER,
*Assistant Engineer.*

Maj. C. B. COMSTOCK,
*Corps of Engineers, U. S. A.*

### DESCRIPTION AND ELEVATION OF PERMANENT BENCH-MARKS.

The elevations all refer to the datum plane of the United States survey of the Mississippi River, according to which the reading of 34.16 feet on the Memphis gauge corresponds to the elevation 68.5794 meters.

*U. S. B. M. "Trotter's Landing."*—Top of copper bolt leaded vertically in top of stone post 1 meter long and 13 centimeters square, set in ground, with top about 5 centimeters above the surface. It is on east side of levee at foot of embankment in J. T. Brames's field, about 6 meters south of where a branch levee runs off toward the east on north side of Mr. Brames's field, and about 65 meters north of where main levee enters field. The stone post is marked with the letters U. S. P. B. M. on top. The elevation of this bench-mark is 58.4706 meters.

*U. S. B. M. "Glendale."*—Top of copper bolt leaded vertically in top of stone post 1 meter long and 13 centimeters square, set in ground, with top about 5 centimeters above surface, in northwest corner of T. C. Ferguson's yard at Glendale, Coahoma County, Mississippi. The stone is marked on top with the letters U. S. P. B. M. The elevation of this bench-mark is 58.3590 meters.

*U. S. B. M. "Delta."*—Top of brass bolt leaded vertically in top of stone post 1 meter long and 13 centimeters square, set in ground, with top about 8 centimeters above surface inside of field, about 17 meters south of levee, and about 625 meters south of where road leading to Delta crosses levee. The stone is marked with the letters U. S. P. B. M. on top. The elevation of this bench-mark is 56.7991 meters.

*U. S. B. M. "Friar's Point I."*—Center of hole in outer end of copper bolt 1 centimeter in diameter, leaded horizontally into brick in southwest wall of jail at Friar's Point, Coahoma County, Mississippi. It is 118 centimeters from west corner of building and 135 centimeters above the ground, in second tier of bricks above water-table. The brick is marked with the letters P. B. M. The elevation of this bench-mark is 57.9261 meters.

*U. S. B. M. "Friar's Point II."*—Center of hole in outer end of copper bolt 1 centimeter in diameter, leaded horizontally in a brick in northeast end of southeast wall of brick building belonging to W. H. Dickerson, at Friar's Point, Coahoma County, Mississippi. The building is in block No. 2 of Fuller's Addition. The elevation of this bench-mark is 57.2970 meters.

*U. S. B. M. "Helena I."*—Center of hole in outer end of copper bolt 1 centimeter in diameter, leaded horizontally into brick in east end of north wall of brick building on west side of Main street, Helena, Ark. The building is the second one south of York street, and is owned by Tenney & Cashman. The elevation of this bench-mark is 60.6381 meters.

*U. S. B. M. "Helena II."*—Center of hole in outer end of copper bolt 1 centimeter in diameter, leaded horizontally into brick in south wall of brick building in northwest corner of Cherry and Rightor streets, Helena, Ark. The building is owned by H. S. & S. H. Horner, and is occupied by McKenzie, Horner & Co., dealers in general merchandise. The bench-mark is 216 centimeters west of southeast corner of building, and 97 centimeters above the sidewalk. The letters P. B. M. are cut in the wall. The elevation of this bench-mark is 60.6446 meters.

| Distance. | Bench-marks. | Difference of elevations of successive bench-marks. | | Mean. | Elevations. | Discrepancy. | |
|---|---|---|---|---|---|---|---|
| | | Forward levels. | Back levels. | | | Partial. | Total. |
| *Metres.* | | *Meters.* | *Meters.* | *Meters.* | *Meters.* | *mm.* | *mm.* |
| | United States bench-mark, "Austin II" | ........ | ........ | ........ | 61.3560 | ........ | ........ |
| | United States bench-mark, "Austin I" | ........ | ........ | ........ | 62.0286 | ........ | ........ |
| 1,550 | Reference-point 1 | +0.4815 | +0.4843 | +0.4829 | 62.5115 | +2.8 | + 2.8 |
| 1,184 | Reference-point 2 | −1.8830 | −1.8829 | −1.8830 | 60.6285 | +0.1 | + 2.9 |
| 838 | Reference-point 3 | −0.1109 | −0.1080 | −0.1094 | 60.5191 | +2.9 | + 5.8 |
| 989 | Reference-point 4 | −1.0514 | −1.0521 | −1.0518 | 59.4673 | −0.7 | + 5.1 |
| 1,315 | Mean of reference-points 5 and 5*a* | +1.9260 | +1.9302 | +1.9281 | 61.3954 | +4.2 | + 9.3 |
| 1,037 | Reference-point 6 | −0.1462 | −0.1450 | −0.1456 | 61.2498 | +1.2 | +10.5 |
| 1,026 | Mean of reference-points 7 and 7*a* | −1.8774 | −1.8785 | −1.8779 | 59.3719 | −1.1 | + 9.4 |
| 730 | Reference-point 8 | +1.6692 | +1.6692 | +1.6692 | 61.0411 | 0.0 | + 9.4 |
| 2,088 | Mean of reference-points 9 and 9*a* | −0.7258* | −0.7226* | −0.7242 | 60.3169 | +3.2 | +12.6 |
| 1,701 | Reference-point 10 | −0.5975 | −0.5973 | −0.5974 | 59.7195 | +0.2 | +12.8 |
| 1,163 | Mean of reference-points 11 and 11*a* | −0.5175 | −0.5167 | −0.5171 | 59.2024 | +0.8 | +13.6 |
| 1,982 | Reference-point 12 | −0.7323 | −0.7288 | −0.7305 | 58.4719 | +3.5 | +17.1 |
| 902 | United States bench-mark, "Trotter's Landing" | −0.0011 | −0.0014 | −0.0013 | 58.4706 | −0.3 | +16.8 |
| 3,192 | Mean of reference-points 13 and 13*a* | +0.3210 | +0.3218 | +0.3214 | 58.7920 | +0.8 | +17.6 |
| 1,272 | United States bench-mark, "Glendale" | −0.4326 | −0.4334 | −0.4330 | 58.3590 | −0.8 | +16.8 |
| 2,152 | Mean of reference-points 14 and 14*a* | −0.8609 | −0.8569 | −0.8589 | 57.5001 | +4.0 | +20.8 |
| 592 | Reference-point 15 | +1.8245 | +1.8207 | +1.8226 | 59.3227 | −3.8 | +17.0 |
| 1,584 | Reference-point 16 | −0.9222 | −0.9237 | −0.9230 | 58.3997 | −1.5 | +15.5 |
| 2,487 | Mean of reference-points 17 and 17*a* | −2.0428 | −2.0393 | −2.0410 | 56.3587 | +3.5 | +19.0 |
| 1,335 | Mean of reference-points 18 and 18*a* | +1.5859 | +1.5881 | +1.5870 | 57.9457 | +2.2 | +21.2 |
| 1,930 | Mean of reference-points 19 and 19*a* | +1.2410 | +1.2383 | +1.2396 | 59.1853 | −2.7 | +18.5 |
| 835 | Reference-point 20 | −0.6658 | −0.6649 | −0.6653 | 58.5200 | +0.9 | +19.4 |
| 2,455 | Mean of reference-points 21 and 21*a* | −1.0899 | −1.0861 | −1.0880 | 57.4320 | +3.8 | +23.2 |
| 2,007 | Reference-point 22 | −0.8558 | −0.8560 | −0.8559 | 56.5761 | −0.2 | +23.0 |
| 523 | United States bench-mark, "Delta" | +0.2227 | +0.2233 | +0.2230 | 56.7991 | +0.6 | +23.6 |
| 3,014 | Reference-point 23 | −0.8035* | −0.7948 | −0.7991 | 56.0000 | +8.7 | +32.3 |
| 2,340 | Reference-point 24 | +1.2743 | +1.2760 | +1.2751 | 57.2751 | +1.7 | +34.0 |
| 1,248 | United States bench-mark, "Friars Point I" | +0.6498 | +0.6523 | +0.6510 | 57.9261 | +2.5 | +36.5 |
| 376 | United States bench-mark, "Friars Point II" | −0.6290 | −0.6292 | −0.6291 | 57.2970 | −0.2 | +36.3 |
| 43,897 | Meters from Austin. | | | | | | |

* Mean of two measurements.

## APPENDIX No. 7.

## CONSTANTS OF TROUGHTON & SIMMS THEODOLITE No. 3.

### REPORT OF MR. R. S. WOODWARD, ASSISTANT ENGINEER.

OFFICE UNITED STATES LAKE SURVEY,
*Detroit, January* 31, 1879.

SIR: During the past three seasons, as occasion has permitted, observations have been made to determine the constants of the Troughton and Simms Theodolite No. 3. These observations have been reduced from time to time, and I herewith respectfully submit the following report giving the results attained, together with such remarks as have seemed necessary to explain the methods adopted in obtaining them:

The constants obtained up to the present time are—

1. Value of the space on the horizontal circle between the graduative marks 359° 55′ and 0°.
2. Values of one division of the striding and vertical circle levels.
3. Constants in the terms of the periodic series eliminated in the mean of the readings of the microscopes of the horizontal circle.
4. Constants in terms of the periodic series *not* eliminated in the mean of the readings of the microscopes of the horizontal circle.

### VALUE OF THE SPACE 359° 55′–0°.

The horizontal circle of this instrument is read by three equidistant micrometer microscopes. When the latter are in adjustment, 5 revolutions of the micrometer screws equal one space on the circle. The micrometer heads are divided into 60 equal parts, so that single seconds may be read directly and tenths of seconds by estimation. In order to ascertain the run of the microscopes at any time, it is necessary to know the value of a space on the circle. To this end 36 spaces, distributed at equal intervals around the circle, were measured in terms of the micrometer screw of Microscope A; at intervals during the measurement of these spaces, several measurements were made of the space 359° 55′–0°, so that its value could be found in terms of the mean of all the spaces, which mean may be assumed to be 5′. The following tables give the results of these observations:

### TABLE I.

[From Note-book E. 548.]

| Time a. m. May 25, 1876. | Space measured. | Value in terms of micrometer screw A. 5 rev. ± | Time a. m. | Space measured. | Value in terms of micrometer screw A. 5 rev. ± |
|---|---|---|---|---|---|
| *h. m.* | ° ′ ° | *div.* | *h. m.* | ° ′ ° | *div.* |
| 9 07 | 359 55 — 0 | + 0.08 | 10 20 | 179 55 — 180 | + 0.07 |
| | 9 55 — 10 | + 0.00 | | 189 55 — 190 | — 0.30 |
| | 19 55 — 20 | — 0.05 | | 199 55 — 200 | + 0.42 |
| | 29 55 — 30 | + 0.50 | 10 35 | 209 55 — 210 | + 0.45 |
| 9 25 | 39 55 — 40 | + 0.70 | | 219 55 — 220 | + 0.15 |
| | 49 55 — 50 | + 0.42 | | 229 55 — 230 | — 0.15 |
| | 59 55 — 60 | + 0.25 | | 239 55 — 240 | + 0.07 |
| 9 37 | 69 55 — 70 | — 0.10 | 10 46 | 249 55 — 250 | — 0.10 |
| | 79 55 — 80 | + 0.35 | | 259 55 — 260 | + 0.00 |
| | 89 55 — 90 | + 1.28 | | 269 55 — 270 | — 0.15 |
| | 99 55 — 100 | + 0.55 | | 279 55 — 280 | + 0.05 |
| 9 50 | 109 55 — 110 | + 0.85 | | 289 55 — 290 | + 0.18 |
| | 119 55 — 120 | + 0.93 | | 299 55 — 300 | + 0.35 |
| | 129 55 — 130 | — 0.53 | | 309 55 — 310 | + 0.25 |
| 10 04 | 139 55 — 140 | + 0.10 | | 319 55 — 320 | + 0.42 |
| | 149 55 — 150 | + 0.23 | | 329 55 — 330 | — 0.25 |
| | 159 55 — 160 | + 0.17 | | 339 55 — 340 | — 0.02 |
| | 169 55 — 170 | — 0.17 | 11 44 | 349 55 — 350 | — 0.15 |

Mean of space in terms of micrometer screw = 5 rev. + 0.1903 divis.

### TABLE II.

| Time a. m. May 25, 1876. | Space measured. | Value in terms of micrometer screw A. 5 rev. |
|---|---|---|
| *h. m.* | ° ′ ° | *div.* |
| 9 07 | 359 55 − 0 | + 0.08 |
| 9 34 | 359 55 − 0 | + 0.12 |
| 10 00 | 359 55 − 0 | + 0.13 |
| 10 25 | 359 55 − 0 | + 0.30 |
| 10 50 | 359 55 − 0 | + 0.00 |
| 11 34 | 359 55 − 0 | + 0.17 |
| 11 49 | 359 55 − 0 | + 0.00 |

Mean value of space in terms of screw = 5 rev. + 0.1143 div.

The value of each space given in the first table is the mean of four independent measurements. For each measurement the micrometer wires were moved across the space measured, so that the effect of any small movement of the microscope with reference to the circle would be rendered as small as possible. Each result in the second table is likewise the result of four separate measurements. As the observations were all made within a period of three hours, the results cannot be vitiated to any appreciable extent by temperature changes.

Denoting the value of the space 359° 55′—0° by $s_0$, and the value of one division of the micrometer head by $d$, it follows from the first table that

$$300.1903\,d = 5' = 300'',$$

or

$$d = \frac{1}{300.1903} \cdot 300''$$

and from the second table

$$s_0 = 300.1143\,d.$$

Substituting the above value of $d$ in the last equation

$$s_0 = \frac{300.1143}{300.1903} \cdot 300'' = 4'\ 59''.\,9241$$

In observing for run of micrometers with this instrument the above space has always been used.

## VALUES OF ONE DIVISION OF STRIDING AND VERTICAL CIRCLE LEVELS.

The values of a division of the levels were found by comparisons made in the spring of 1877 with the level trier of the Lake Survey. The mean value of 1 division of the striding level for a space of about 12 divisions on either side of the middle of the level tube was found to be 0″.898 at a temperature of 60° F.

The mean value of 1 division of the vertical circle level for a space of about 20 divisions on either side of the middle of the tube was found to be 1″.026, at a temperature of 64° F.

No determinations at other temperatures have been made for either level. The computations of the above values are given in MS. report No. 788.

## PERIODIC ERRORS ELIMINATED IN THE MEAN OF THE MICROSCOPE READINGS.

In the spring of 1876 the readings of the microscopes at 12 equidistant points on the horizontal circle were carefully observed, and from these observations the first three terms of the periodic series* eliminated in the mean of the microscope readings were computed. The correction to the reading of any microscope for this periodic error was found to be $+2''.71 \sin(z + 152°) + 2''.10 \sin(2z + 245°) + 0''.48 \sin(4z + 51°)$, wherein $z$ is the reading of the microscope.

The observations from which the above series was computed are recorded in note-book E 548.

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* See equation (32) p. 52, vol. II, Chauvenet's Astronomy. It should be observed that the term in $z$ is not necessarily due to eccentricity.

## PERIODIC ERRORS NOT ELIMINATED IN THE MEAN OF THE MICROSCOPE READINGS.

Of much more importance than the preceding periodic error is that *not* eliminated in the mean of the microscope readings, and I have therefore taken great pains to determine its nature and extent. In the following pages I have taken up the investigation of this class of errors, in the general case of a circle read by any number of equidistant microscopes, at the point where it is dropped by Chauvenet,[*] and have indicated briefly the effect of such errors on observed angles, shown how they may be eliminated, and how the constants of the different terms of the series may be determined. The formulas derived are then applied to compute the constants of the terms of the periodic error series affecting angles observed with the Troughton & Simms theodolite No. 3.

In measuring angles with this instrument the observations have generally been so arranged that the mean of the several separate measurements would be free from periodic error. In a few cases, however, it has been impossible to do this, and some results have been obtained which should be corrected, if used in the computations of the primary triangulation.

## THEORY OF PERIODIC ERRORS NOT ELIMINATED IN THE MEAN OF THE READINGS ON A CIRCLE OF ANY NUMBER OF EQUIDISTANT MICROSCOPES.

The periodic error not eliminated in the mean of the readings of $q$ equidistant microscopes may be expressed by the series

$$\Sigma\, u_r \sin\,(rqz+\beta_r),\dagger$$

wherein $z$ is the reading of the initial microscope, $u_r$ and $\beta_r$ are constants, and $r$ is 1, 2, 3, &c., for the respective terms of the series.

To determine the effect of this error on an angle observed between two objects, let

$R_1=$ the mean reading of the $q$ microscopes on the first object,
$R_2=$ the mean reading on the second object,
$a=$ the true value of the angle.

Then the correction to $R_1$ is

$$\Sigma\, u_r \sin\,(rqz+\beta_r);$$

and supposing the graduation to increase from $R_1$ to $R_2$, the correction to $R_2$ is

$$\Sigma\, u_r \sin\,(rqz+rqa+\beta_r).$$

Hence,

$$a=R_2-R_1+\Sigma\, u_r \sin\,(rqz+rqa+\beta_r)-\Sigma\, u_r \sin\,(rqz+\beta_r)$$

or by reduction;

$$(1)\qquad a=R_2-R_1+2\,\Sigma\, u_r \cos\,(rqz+\tfrac{r}{2}qa+\beta_r)\sin\tfrac{r}{2}qa.$$

The periodic part of this equation vanishes whenever the angle observed is equal to the angular distance between any two microscopes, since in that case

$$\sin\tfrac{r}{2}qa=\sin rp\,\pi=o,\ p \text{ being an integer.}$$

Putting for brevity

$$w_r=rqz+\tfrac{r}{2}qa+\beta_r,$$

equation (1) may be written,

$$(2)\qquad \begin{aligned} a=R_2-R_1&+2\,u_1\sin\tfrac{1}{2}qa\cos w_1\\ &+2\,u_2\sin qa\cos w_2\\ &+2\,u_3\sin\tfrac{3}{2}qa\cos w_3\\ &+\text{etc.}\end{aligned}$$

It is apparent from this equation that, by using suitable values for $z$, some of the terms of the periodic part may be eliminated in the mean of a number of measurements of $a$. This may be best accomplished as follows: Let $a$ be observed on all the successive parts of the circle represented by $z_m=z+m\frac{2\pi}{nq}$,‡ $m$ being successively 1,

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[*] See Article 35, pp. 51, 52, and 53, Astronomy, vol. II.

[†] See equation (33) page 53, Chauvenet's Astronomy, vol. II. The reading of either microscope might be taken for $z$. It need be taken only to the nearest degree.

[‡] It will be observed that $\frac{2\pi}{q}$ is the distance between consecutive microscopes, and hence the equation supposes this distance divided into $n$ equal parts.

2, 3 . . . . . $(n-1)$. Then will there be $n$ equations of the form (2); and denoting the different values of $R_1$ and $R_2$ by accents, the type equation will be

$$(3)\quad a = R_2^{(m+1)} - R_1^{(m+1)} + 2u_1 \sin \tfrac{1}{2} qa \cos\left(w_1 + m\frac{2\pi}{n}\right)$$
$$+ 2u_2 \sin qa \cos\left(w_2 + m\frac{4\pi}{n}\right)$$
$$+ 2u_3 \sin \tfrac{3}{2} qa \cos\left(w_3 + m\frac{6\pi}{n}\right)$$
$$+ \text{etc.}$$

The sum of these equations is

$$na = \Sigma\left(R_2^{(m+1)} - R_1^{(m+1)}\right) + 2u_1 \sin \tfrac{1}{2} qa \,\Sigma \cos\left(w_1 + m\frac{2\pi}{n}\right)$$
$$+ 2u_2 \sin qa \,\Sigma \cos\left(w_2 + m\frac{4\pi}{n}\right)$$
$$+ 2u_3 \sin \tfrac{3}{2} qa \,\Sigma \cos\left(w_3 + m\frac{6\pi}{n}\right)$$
$$+ \text{etc.}$$

But in the latter all the terms of the periodic part vanish except the $n^{\text{th}}$, $2n^{\text{th}}$, $3n^{\text{th}}$ &c., which become respectively,

$$2nu_n \sin \frac{n}{2} qa \cos w_n,\ 2nu_{2n} \sin nqa \cos w_{2n},\ \text{etc.},$$

Hence

$$(4)\quad a = \frac{\Sigma\left(R_2^{(m+1)} - R_1^{(m+1)}\right)}{n} + 2u_n \sin \frac{n}{2} qa \cos w_n;$$
$$+ 2u_{2n} \sin uqa \cos w_{2n}$$
$$+ \text{etc.}$$

In general, $n$ may be taken so large as to render the periodic part of the last equation unappreciable, and on this supposition $a$ will be given with the required degree of accuracy by the equation,

$$(5)\quad a = \frac{\Sigma\left(R_2^{(m+1)} - R^{(m+1)}\right)}{n}$$

To find the constants $u_1$, $u_2$, &c., $\beta_1$, $\beta_2$, &c., the value of $a$ given by (5) being substituted in (3) gives putting $v^{(m+1)} = a - \left(R_2^{(m+1)} - R_1^{(m+1)}\right)$, and developing the cosines in the second member.

$$v^{(m+1)} = 2 \sin \tfrac{1}{2} qa \left(\cos m\frac{2\pi}{n} u_1 \cos w_1 - \sin m\frac{2\pi}{n} u_1 \sin w_1\right)$$
$$+ 2 \sin qa \left(\cos m\frac{4\pi}{n} u_2 \cos w_2 - \sin m\frac{4\pi}{n} u_2 \sin w_2\right)$$
$$+ 2 \sin \tfrac{3}{2} qa \left(\cos m\frac{6\pi}{n} w_3 \cos w_3 - \sin m\frac{6\pi}{n} u_3 \sin w_3\right)$$
$$+ \text{etc.}$$

Regarding $u_1 \cos w_1$, $u_1 \sin w_1$, $u_2 \cos w_2$, $u_2 \sin w_2$, &c., as the unknown quantities in the equations of which the above is the type, it follows that

$$\left\{\begin{aligned} nu_1 \cos w_1 &= \frac{\Sigma v^{(m+1)} \cos m\frac{2\pi}{n}}{\sin \frac{1}{2} qa} \\ nu_1 \sin w_1 &= -\frac{\Sigma v^{(m+1)} \sin m\frac{2\pi}{n}}{\sin \frac{1}{2} qa} \end{aligned}\right.$$

$$(6)\quad \left\{\begin{aligned} nu_2 \cos w_2 &= \frac{\Sigma v^{(m+1)} \cos m\frac{4\pi}{n}}{\sin qa} \\ nu_2 \sin w_2 &= -\frac{\Sigma v^{(m+1)} \sin m\frac{4\pi}{n}}{\sin qa} \end{aligned}\right.$$

$$\left\{\begin{aligned} nu_3 \cos w_3 &= \frac{\Sigma v^{(m+1)} \cos m \frac{6\pi}{n}}{\sin \frac{3}{2} qa} \\ nu_3 \sin w_3 &= -\frac{\Sigma v^{(m+1)} \sin m \frac{6\pi}{n}}{\sin \frac{3}{2} qa} \end{aligned}\right.$$

$$\text{etc.} \qquad \text{etc.}$$

These equations will determine $u_1$, $w_1$, $u_2$, $w_2$, &c. Then, since

$$(7) \qquad \begin{aligned} w_1 &= qz + \tfrac{1}{2} qa + \beta_1, \\ w_2 &= 2qz + qa + \beta_2, \\ &\text{etc.} \qquad \text{etc.} \end{aligned}$$

$\beta_1$, $\beta_2$, &c., may be found.

When a number of values of $u_1$, $\beta_1$, $u_2$, $\beta_2$, &c., have been computed from the residuals, $v^{(m+1)}$ resulting from observations on different angles, in order to combine them so as to obtain the most probable result, it is necessary to know their relative weights. Referring to equations (7) it appears that the weight of $\beta_1$ is the same as the weight $w_1$, the weight of $\beta_2$ the same as that of $w_2$, &c. From equations (6)

$$u_r \cos w_r = \frac{\Sigma v^{(m+1)} \cos m \frac{r 2\pi}{n}}{n \sin \frac{r}{2} qa}.$$

$$u_r \sin w_r = -\frac{\Sigma v^{(m+1)} \sin m \frac{r 2\pi}{n}}{n \sin \frac{r}{2} qa}.$$

For brevity put

$$x = \frac{\Sigma v^{(m+1)} \cos m \frac{r 2\pi}{n}}{n \sin \frac{r}{2} qa}.$$

$$(8)$$

$$y = -\frac{\Sigma v^{(m+1)} \sin m \frac{r 2\pi}{n}}{n \sin \frac{r}{2} qa}.$$

Then, since

$$u_r \cos w_r = x$$
$$u_r \sin w_r = y$$

$$(9) \qquad \begin{aligned} u_r &= (x^2 + y^2)^{\frac{1}{2}} \\ w_r &= \tan^{-1} \frac{y}{x}. \end{aligned}$$

Let—

$$E_{u_r} = \text{mean error of } u_r$$
$$E_{w_r} = \text{mean error of } w_r.$$

Then supposing the mean errors of the residuals $r^{(m+1)}$ to be each unity, it follows that—

$$(10) \qquad E^2_{u_r} = \Sigma \left( \frac{du_r}{dx} \frac{dx}{dv^{(m+1)}} + \frac{du_r}{dy} \cdot \frac{dy}{dv^{m+1}} \right)^{2*}$$

$$E^2_{w_r} - \left( \frac{dw_r}{dx} \frac{dx}{dv^{(m+1)}} + \frac{dw_r}{dy} \cdot \frac{dy}{dv^{(m+1)}} \right)^2$$

in which $m$ is successively 1, 2, 3 ..... $(n+1)$ as heretofore. From equations (8) and (9)

$$\frac{du_r}{dx} = \frac{x}{(x^2+y^2)^{\frac{1}{2}}} \cdot \frac{du_r}{dy} = \frac{y}{(x^2+y^2)^{\frac{1}{2}}}.$$

$$\frac{dw_r}{dx} = -\frac{x}{x^2+y^2} \cdot \frac{dw_r}{dy} = \frac{x}{x^2+y^2}.$$

$$\frac{dx}{(m+1)} = \frac{\cos m \frac{r2\pi}{n}}{n \sin \frac{r}{2} qa} \cdot \frac{dy}{dv^{m+1}} = -\frac{\sin m \frac{r2\pi}{n}}{n \sin \frac{1^1}{2} qa}$$

---

* See Chauvenet's Astronomy, vol. II, art. 23, page 502.

Substituting these values in equations (10) and reducing

$$
(11)\qquad
\begin{aligned}
E^2_{u_r} &= \frac{1}{2n\sin^2\frac{r}{2}qa} \\[2ex]
E^2_{w_r} &= \frac{1}{2nu_r^2\sin^2\frac{r}{2}qa}
\end{aligned}
$$

Hence the weights of $u_r$ and $w_r$ or $\beta_r$ vary as $n\sin^2\frac{r}{2}qa$.

### DETERMINATION OF CONSTANTS $u_1$ AND $\beta_1$ FOR TROUGHTON & SIMMS THEODOLITE NO. 3.

For an instrument reading by three equidistant microscopes, equation (1) becomes

$$
\begin{aligned}
a = R_2 - R_1 &+ 2u_1\cos(3z + \tfrac{3}{2}a + \beta_1)\sin\tfrac{3}{2}a \\
&+ 2u_2\cos(6z + 3a + \beta_2)\sin 3a \\
&+ 2u_3\cos(9z + \tfrac{9}{2}a + \beta_3)\sin\tfrac{9}{2}a \\
&+ \text{etc.}
\end{aligned}
$$

From this it appears that in the mean of two measurements of $a_1$ with initial microscope reading $z$ for one and $180° + z$ for the other, the odd terms of the periodic series are eliminated. In using the T. & S. theodolite No. 3, it has been customary to follow this consideration. The reading of the initial microscope may be changed from $z$ to $180° + z$, either by shifting the circle 180° or by transiting the telescope and turning the alidade 180°. The latter method has been followed; and as the vertical circle of the instrument is on the right of the observer for one result and on the left for the other, the observed values of the angle $(R_2 - R_1)$ may be conveniently designated by

$A_r$ for vertical circle right, $z_r = z$
$A_l$ for verticle circle left, $z_l = 180° + z$

These values substituted in the above equation give

$$
\begin{aligned}
a = A_r &+ 2u_1\cos w_1\sin\tfrac{3}{2}a \\
&+ 2u_2\cos w_2\sin 3a \\
&+ \text{\&c.}
\end{aligned}
$$

and

$$
\begin{aligned}
a = A_l &- 2u_1\cos w_1\sin\tfrac{3}{2}a \\
&+ 2u_2\cos w_2\sin 3a \\
&- \text{\&c.}
\end{aligned}
$$

Taking the sum and difference of these

$$
(a)\qquad
\begin{aligned}
a - \frac{A_r + A_l}{2} &= 2u_2\cos w_2\sin 3a \\
&+ 2u_4\cos w_4\sin 6a \\
&+ \text{\&c.}
\end{aligned}
$$

$$
(b)\qquad
\begin{aligned}
-\frac{A_r - A_l}{2} &= 2u_1\cos w_1\sin\tfrac{3}{2}a \\
&+ 2u_3\cos w_3\sin\tfrac{9}{2}a \\
&+ \text{etc.}
\end{aligned}
$$

In MS. report No. 887 the values of $A_r + A_l$ have been computed for twenty-six angles. From an inspection of these values it is evident that the even terms expressed by equation ($a$) are insignificant. The application of the second and fourth of formulas (6), using such values of $a$ that $\sin 3a$ and $\sin 6a$ are near unity, shows that the coefficients $u_2$ and $u_4$ are inappreciable.

In the computation herewith appended the constants $u_1$ and $\beta_1$ for the first odd term of the series have been deduced from the observations on ten different angles. The appropriate formulas for computing the constants for the higher odd terms have also been applied, but do not give values for the coefficients $u_3$, $u_5$ larger than would be concealed by the errors involved in the residuals $v$.

As the angles from the measurements of which $u_1$ and $\beta_1$ have been computed were all read in the manner explained above, the quantities $v^{(m+1)}$ have been derived from the equation $v^{(m+1)} = -\frac{A_l(m+1) - A_l(m+1)}{2}$, corresponding to equation ($b$) above.

The weighted mean values of $u_1$ and $\beta_1$ resulting from the computation are

$$
\begin{aligned}
u_1 &= 0''.936 \\
\beta_1 &= 147°
\end{aligned}
$$

These substituted in equation (1) give

$$a = R_2 - R_1 + 1''.87 \cos(3z + \tfrac{3}{2}a + 147^\circ) \sin \tfrac{3}{2}a,$$

or

$$v = 1''.87 \cos(3z + \tfrac{3}{2}a + 147^\circ) \sin \tfrac{3}{2}a.$$

For a numerical maximum of $v$,

$$a = 60^\circ \text{ and } z = 281^\circ \text{ or } 341^\circ$$
$$a = 180^\circ \text{ and } z = 221^\circ \text{ or } 281^\circ$$
$$a = 300^\circ \text{ and } z = 161^\circ \text{ or } 221^\circ$$

For any value of $a$,

$$v = o \text{ when } z = -\frac{a}{2} - 19^\circ \text{ or } -\frac{a}{2} + 41^\circ.$$

Also,

$$v = o \text{ when } a = \tfrac{2}{3} p \pi, \text{ p being an integer or zero.}$$

To further illustrate the application of the formula derived, the following table has been constructed from the measurements of an angle not involved in the computation of the constants $u_1$ and $\beta_1$. The headings of the columns are in accordance with the notation explained.

*Angle at Sodus Station between Walworth and Palmyra.*

$a = 312^\circ 52'$ $n = 12$ $\frac{2\pi}{nq} = 10^\circ$ $v = 1''.87 \cos(3Z + \tfrac{3}{2}a + 147^\circ) \sin \tfrac{3}{2}a.$

| $Z_r$. | Observed values of— | | | Computed values of $v$. | Corrected values of— | |
|---|---|---|---|---|---|---|
| | $A_r$. | $A_l$. | $v = -\frac{A_r - A_l}{2}$ | | $A_r$. | $A_l$. |
| ° | ″ | ″ | ″ | ″ | ″ | ″ |
| 149 | 42.45 | 46.25 | + 1.90 | + 1.69 | 44.14 | 44.56 |
| 159 | 43.80 | 47.05 | + 1.62 | + 1.72 | 45.52 | 45.33 |
| 169 | 43.15 | 46.70 | + 1.77 | + 1.29 | 44.44 | 45.41 |
| 179 | 44.05 | 46.50 | + 1.22 | + 0.52 | 44.57 | 45.98 |
| 189 | 45.95 | 45.25 | − 0.35 | − 0.40 | 45.55 | 45.65 |
| 199 | 46.70 | 44.75 | − 0.97 | − 1.21 | 45.49 | 45.96 |
| 209 | 46.85 | 44.20 | − 1.32 | − 1.69 | 45.16 | 45.89 |
| 219 | 45.50 | 42.15 | − 1.67 | − 1.72 | 43.78 | 43.87 |
| 229 | 46.25 | 44.10 | − 1.07 | − 1.29 | 44.96 | 45.39 |
| 239 | 46.75 | 45.20 | − 0.77 | − 0.52 | 46.23 | 45.72 |
| 249 | 44.90 | 44.30 | − 0.30 | + 0.40 | 45.30 | 43.90 |
| 259 | 43.70 | 45.40 | + 0.85 | + 1.21 | 44.91 | 44.19 |
| Sums | 60.05 | 61.85 | | | 60.05 | 61.85 |

**Mean angle $a = 312^\circ 52' 45''.08$.**

A partial test of the accuracy of the periodic formula is afforded by a comparison of the observed and computed values of the residuals $v$.

The computed values, $v$, are applied directly to the results $A_r$, and with their signs changed to the results $A_l$, to produce the last two columns.

*Results of computation of $u_1$, $\beta_1$, and relative weights from ten measured angles.*

| $a$. | | | $\beta_1$. | $u_1$. | $n \sin^2 \frac{3}{2}a$. | $n \sin^2 \frac{3}{2}a$. | $n u_1 \sin^2 \frac{3}{2}a$. |
|---|---|---|---|---|---|---|---|
| ° | ′ | ″ | ° | ″ | | ° | ″ |
| 59 | 47 | 28.46 | 149 | 0.779 | 10.000 | 1,490.0 | 7.790 |
| 54 | 48 | 16.32 | 141 | 1,044 | 11.779 | 1,660.9 | 12.299 |
| 58 | 27 | 40.66 | 145 | 0.898 | 11.980 | 1,737.2 | 10.766 |
| 179 | 38 | 55.76 | 151 | 0.916 | 11.999 | 1,811.8 | 10.997 |
| 74 | 25 | 05.55 | 149 | 0,966 | 10.371 | 1,545.4 | 10.025 |
| 46 | 10 | 51.83 | 142 | 0.082 | 10.496 | 1,490.4 | 8.732 |
| 52 | 38 | 50.72 | 149 | 1.154 | 7.703 | 1,148.3 | 8.897 |
| 44 | 14 | 59.27 | 152 | 0.964 | 6.714 | 1,020.6 | 6.472 |
| 47 | 31 | 33.58 | 137 | 0.992 | 7.176 | 983.1 | 7,117 |
| 57 | 55 | 16.35 | 152 | 0.869 | 7.976 | 1,212.4 | 6.936 |
| Sums | | | | | 96.198 | 14,100.1 | 90.031 |
| Weighted means | | | 146°.57 | 0″.9357 | | | |

Very respectfully,

R. S. WOODWARD,
*Assistant Engineer.*

General C. B. COMSTOCK,
*Superintendent U. S. Lake Survey.*

## APPENDIX No. 8.

## ERRORS OF CERTAIN THERMOMETERS.

### REPORT OF MR. THOMAS RUSSELL, ASSISTANT ENGINEER.

OFFICE OF SURVEYS OF NORTHERN AND NORTHWESTERN
LAKES AND MISSISSIPPI RIVER,
*Detroit, Mich., May* 25, 1879.

GENERAL: In accordance with your instructions, I have the honor to make the following report on the calibration of thermometer Baudin 6131, its corrections at freezing and boiling points, and on the corrections of Cassella Nos. 21472, 21473, 21474, 21475, and 21476; $A_1$, $A_2$, $A_3$, $A_4$, $B_1$, $B_2$, $B_3$, $B_4$ of the Clarke yards A and B, and Geissler Nos. 1, 2, 3, and 4.

The bulb of Baudin 6131 was cracked January 3, 1879, while trying to detach a column of mercury with which to calibrate it. The thermometer was sent to James Green, New York, and another bulb blown on. It was received here February 21, 1879.

The following are the dimensions, in inches, of this thermometer as repaired: Total length, $17\frac{1}{8}$; distance from 0° to 100°, $13\frac{5}{16}$; length of bulb, $1\frac{1}{4}$; diameter of stem, $\frac{3}{16}$; diameter of bulb, $\frac{5}{16}$. The thermometer is graduated according to the Centigrade scale; to fifths of a degree, from —1.0° to + 101°.0.

### CALIBRATION.

The calibration corrections of a Centigrade thermometer are the corrections to be applied to the division lines as subdividing into parts of equal capacity the tube from the line 0° to the line 100°. These corrections were determined for Baudin 6131 with columns of 50°.2, 24°.9, and 10°.1. The columns were placed in various parts of the tube, and the readings of the ends determined with a microscope having a micrometer attachment. The focus of the microscope was fixed for a point between the mercury and the graduation, which caused indistinctness of both images. The micrometer was read on the mercury, and the graduation above and below it; from these, by dividing the difference between the reading on one graduation and the mercury by the difference between the two graduations the fractional part of the reading of the end of the column was obtained. The difference of the readings of the two ends of the column gave the length of the column at that part of the tube. From the various measured lengths of the columns the calibration corrections were derived.

Denote the measured lengths of the columns according to the part of the scale on which they are made by $[0\cdot50]$ $[5\cdot30]$ $[15\cdot25]$, &c. In the tables following, these quantities are usually the means of two or more measurements. Denote the mean of $[0\cdot50]$ $[50\cdot100]$ by $(C_{50})$, the mean of $[0\cdot25]$ $[25\cdot50]$ $[50\cdot75]$ $[75\cdot100]$ by $(C_{25})$, and the mean of $[0\cdot10]$ $[10\cdot20]$ $[20\cdot30]$ $[30\cdot40]$ $[40\cdot50]$ by $(C_{10})$. Denote the true lengths, expressed in degrees (the degree being $\frac{1}{100}$ of the capacity of the tube between 0° and 100°) of the columns by $C_{50}$, $C_{25}$, $C_{10}$. Denote the calibration corrections at the points 5°, 10°, 15°, &c., by $\phi(5)$, $\phi(10)$, $\phi(15)$, &c. Then from the 25° column these equations follow:

$$\begin{aligned} C_{25} &= [\ 0\cdot25] + \phi(25) \\ C_{25} &= [25\cdot50] - \phi(25) + \phi(50) \\ C_{25} &= [50\cdot75] - \phi(50) + \phi(75) \\ C_{25} &= [75\cdot100] - \phi(75) \end{aligned}$$

Summing up these equations and dividing by 4 we have

$$C_{25} = \frac{[0\cdot25] + [25\cdot50] + [50.75] + 75\cdot100]}{4};$$

that is, the quantity which has been denoted by $(C_{25})$ is equal to the true length of the column, or $C_{25}$. Making this substitution and transposing, the expressions for the corrections at 25°, 50°, and 75° are as follows:

$$\begin{aligned} \phi(25) &= (C_{25}) - [0\cdot25] \\ \phi(50) &= \phi(25) + (C_{25}) - [25\cdot50] \\ \phi(75) &= \phi(50) + (C_{25}) - [50\cdot75] \end{aligned}$$

From the 50° column we get in the same way:

$$\phi(50) = (C_{50}) - [0\cdot50]$$

With equations formed by the 10° column it will be found that:

$$C_{10} = (C_{10}) + \tfrac{1}{5}\phi(50)$$

By substituting, the corrections at 10°, 20°, 30°, 40° will be found to be:

$$\begin{aligned} \phi(10) &= (C_{10}) + \tfrac{1}{5}\phi(50) - [0\cdot10] \\ \phi(20) &= \phi(10) + (C_{10}) + \tfrac{1}{5}\phi(50) - [10\cdot20] \end{aligned}$$

A system of measurements with the 25° column was also made from 0° to 25°, 5° to 30°, 10° to 35°, and 15° to 40°. Before using these to determine the corrections at the points 5°, 35°, and 15°, the columns were corrected by the difference in the measurements of [0·25] in the two systems. This correction was applied as the temperature of the column was not the same in the two systems, aud its length not the same in consequence. The expressions for these corrections are then:

$$\phi(5) = \phi(30) - \left\{ (C_{25}) - \overset{\text{cor't'd}}{[\,5\cdot30\,]} \right\}$$

$$\phi(35) = \phi(10) + \left\{ (C_{25}) - \overset{\text{cor't'd}}{[\,10\cdot30\,]} \right\}$$

$$\phi(15) = \phi(40) - \left\{ (C_{25}) - \overset{\text{cor't'd}}{[\,15\cdot40\,]} \right\}$$

The corrections at 5° and 35° may also be derived in the same way from the 10° column. Where there are two values of the calibration correction at the same point the mean is adopted. On the following pages the observations and results are given:

## CALIBRATION OF BAUDIN 6131.

### *April* 14 *and* 15.

[50° column. Temp. of air, 77° and 72° F.]

| Space. | Measured lengths. | | | | Means. |
|---|---|---|---|---|---|
| | 1st. | 2d. | 3d. | 4th. | |
| | ° | ° | ° | ° | ° |
| [ 0– 50] | 50. 231 | 50. 240 | 50. 230 | 50. 240 | 50. 235 |
| [50–100] | 50. 153 | . 149 | . 120 | . 119<br>. 152 | 50. 139 |
| | | | | | $(C_{50})$ = 50. 187 |

### *April* 15 *and* 16.

[25° column. Temp. of air, 72°.]

| Space. | Measured lengths. | | Means. |
|---|---|---|---|
| | 1st. | 2d. | |
| | ° | ° | ° |
| [ 0– 25] | 24. 888 | 24. 911 | 24. 900 |
| [25– 50] | 24. 987 | 25. 000 | 24. 993 |
| [50– 75] | 24. 894 | 24. 882 | 24. 888 |
| [75–100] | 24. 887 | 24. 886 | 24. 886 |
| | | | $(C_{25})$ = 24. 917 |
| [ 0– 25] | 24. 935 | 24. 922 | 24. 928 |
| [ 5– 30] | 24. 902 | 24. 903 | 24. 902 |
| [10– 35] | 24. 934 | 24. 938 | 24. 936 |
| [15– 40] | 24. 960 | 24. 946 | 24. 953 |

### *April* 16.

[10° column. Temp. of air, 70°.]

| Space. | Measured lengths. | | Means. |
|---|---|---|---|
| | 1st. | 2d. | |
| | ° | ° | ° |
| [0–10] | 10.130 | 10.128 | 10.129 |
| [5–15] | .138 | .......... | .138 |
| [10–20] | .079 | .096 | .088 |
| [15–25] | .095 | .......... | .095 |
| [20–30] | .163 | .166 | .164 |
| [25–35] | .158 | .157 | .158 |
| [30–40] | .166 | .167 | .166 |
| [35–45] | .165 | .......... | .165 |
| [40–50] | .144 | .147 | .146 |
| | | | $(C_{10})$ = 10.139 |

### *April* 15.

[25° column. Temp. of air, 72°.]

| Space. | Measured lengths. | | | | Means. |
|---|---|---|---|---|---|
| | 1st. | 2d. | 3d. | 4th. | |
| | ° | ° | ° | ° | ° |
| [0–25] | 24.906 | 24.914 | 24.916 | 24.915 | 24.913 |
| [25–50] | 25.006 | 25.010 | 25.013 | 25.015 | 25.011 |
| | | | | | $(C_{25})$ = 24.962 |

From the 50° column [0–50] [50–100] the correction at 50° is found to be —0°.048. The correction at the same point, obtained by means of the 25° column, is —0°.059.

The mean of these values is adopted as the correction at 50°, and with this and the spaces measured by the 25° and 10° columns the calibration corrections at the points between 0° and 50°, given below, are found.

### CALIBRATION CORRECTIONS, BAUDIN 6131.

| Temp. | 10° col. | 25° col. | Cal. cor. C., mean. |
|---|---|---|---|
| ° | | | ° |
| 5 C. | −0.010 | −0.036 | −0.023 |
| 10 C. | .......... | .......... | −0.001 |
| 15 C. | −0.012 | −0.028 | −0.020 |
| 20 C. | .......... | .......... | +0.039 |
| 25 C. | .......... | .......... | +0.021 |
| 30 C. | .......... | .......... | +0.003 |
| 35 C. | −0.009 | +0.008 | 0.000 |
| 40 C. | .......... | .......... | −0.036 |
| 45 C. | .......... | .......... | −0.037 |
| 50 C. | .......... | .......... | −0.054 |
| 75 C. | .......... | .......... | −0.030 |

### BOILING POINT.

Two determinations of the boiling point of Baudin 6131 were made, one March 26 and the other April 14. The thermometer was in the vapor of boiling water about twenty minutes before readings were made. It was observed both in a horizontal and vertical position. The difference in the readings in the two positions was found to be 0°.18 Cent., the reading being greater when horizontal. A determination of freezing point was made just after each boiling, allowing fifteen minutes for the thermometer to cool before packing in ice.

When the thermometer was observed in vapor of boiling water, readings of standard barometer No. 1274, James Green, were made about the same time. The boiling water was at about the level of the barometer cistern.

In the annual report of the Lake Survey for 1861 (page 199) the correction to reduce the readings of No. 1274 to true barometric height is $-0^{\text{in}}.006$.

This correction is the result of comparisons made at Cambridge, Mass., by W. C. Bond, between it and barometer Newmann No. 57. Newmann No. 57 had been previously compared with the Royal Society standard in London, and there was found to be no difference between them. On account of the considerable time since the comparison of 1274 with Newmann No. 57, it was considered advisable to have a check on its correction. For that purpose the barometer was taken to the office of the Signal Service in Detroit, and compared with "signal-service barometer No. 352." The result of the comparison showed that the correction is about the same as that found in 1861.

The height of the ground in the vicinity of the Lake-Survey office is about 601 feet above sea-level; the height of the barometer cistern above the ground was 29 feet. The correction to be applied to the observed barometer heights for elevation above sea-level and to reduce to latitude 45°, the latitude of Detroit being 42° 20′, is $-0^{\text{in}}.007$, so that the total correction to be applied to the barometer readings, in addition to the reduction to $0^\circ.0$ Cent., is $-0^{\text{in}}.013$.

When there was an excess of pressure inside of the vessel containing the boiling water, as shown by a water-gauge made of a glass U-shaped tube attached to it, the proper correction was made for it.

The line 100° on Centigrade thermometers represents the temperature of steam under a standard pressure, or a barometric reading in the latitude 45° at sea-level of 0.760 of a meter after correction to 0° Cent.

The method of deriving the correction to any reading for the error in the relative position of the 100° and the 0° mark on the thermometer is as follows:

Denoting by $r_v$ the reading of the thermometer in vapor of boiling water, by $t_v$ the temperature of the vapor taken from the tables with the corrected barometer readings, and by $f$, the reading of the thermometer in melting ice just after boiling, then $(r_v - f)$ will be the difference in the thermometer readings which corresponds to a change in temperature between 0° and the temperature $t_v$. The value in centigrade degrees of a unit of the thermometer scale is then $\frac{t_v}{r_v - f}$. Boiling a thermometer lowers its freezing point, and the freezing point rises rapidly afterward. Taking $f'$ as the reading in melting ice at any time, then for any other reading of the thermometer $t$, the corresponding centigrade temperature (not considering calibration errors) will be $(t - f')\left(\frac{t_v}{r_v - f}\right)$ and denoting by $x$ the scale correction for any point $t$, it becomes:

$$x = (t - f')\left(\frac{t_v}{r_v - f}\right) - t$$

The scale corrections of Baudin 6131 are given for $f' = +0^\circ.2$ Cent. A change in $f$ of $0^\circ.12$ will cause a change in the scale corrections of $0^\circ.001$.

BAUDIN 6131, HORIZONTAL.

| Ther. reading. | Scale. cor. Cent. |
|---|---|
| ° | ° |
| 5 | +0.041 |
| 10 | +0.083 |
| 15 | +0.125 |
| 20 | +0.168 |
| 25 | +0.210 |
| 30 | +0.252 |
| 35 | +0.295 |
| 40 | +0.337 |
| 45 | +0.379 |
| 50 | +0.422 |

The correction to a thermometer reading may be taken as consisting of two parts, that at freezing point, $a$, which is a constant for all points, but varies with the time; and $b$, the sum of the calibration correction and the correction due to the error in the relative position of the freezing point and the boiling point, which is a constant, as regards the time, but varies for different points of the thermometer.

### *Correction due to error in relative position of freezing and boiling points.*

### BAUDIN 6131, HORIZONTAL.

| Date. | Observed boiling point. | Barometer 1274, corrected. | Computed boiling point. | Correction at boiling point. | Observed freezing point. | Corrected to scale. |
|---|---|---|---|---|---|---|
| | ° | *Inch.* | ° | ° | ° | ° |
| March 26, 1879 | 98.451 | 29.082 | 99.205 | +0.754 | +0.060 | +0.814 |
| April 14, 1879 | 98.568 | 29.173 | 99.294 | +0.726 | +0.127 | +0.853 |
| Mean | | | | | | +0.834 |

### BAUDIN 6131, HORIZONTAL IN MELTING ICE.

| Date. | Thermometer reading (Centigrade). | Correction at freezing point = *a*. |
|---|---|---|
| | ° | ° |
| April, 9, 1879 | +0.177 | |
| April 12, 1879 | +0.199 | |
| Mean | +0.188 | −0.188 |
| May 14, 1879 | +0.244 | |
| May 15, 1879 | +0.250 | |
| May 16, 1879 | +0.262 | |
| Mean | +0.252 | −0.252 |

Thermometer in vapor of boiling water April 14.

### BAUDIN 6131, HORIZONTAL.

| Thermometer reading (Centigrade). | Calibration and scale corrections = *b*. |
|---|---|
| ° | ° |
| 0 | 0.0 |
| 5 | +0.018 |
| 10 | +0.082 |
| 15 | +0.105 |
| 20 | +0.207 |
| 25 | +0.231 |
| 30 | +0.255 |
| 35 | +0.295 |
| 40 | +0.301 |
| 45 | +0.342 |
| 50 | +0.368 |

### COMPARISONS.

Baudin 6131 was compared horizontally in water with Cassella 21472, 21474, 21476, $A_1$, $A_2$, $A_3$, $A_4$, and $B_1$, $B_2$, $B_3$, $B_4$. The thermometers were placed with the stems parallel, and the bulbs very close together. The water covered them to the depth of 1½ inches. The tank in which they were placed is 3 feet by 1 foot and 1½ feet deep. During the time the comparisons were being made the temperature of the air in the room was kept, as near as practicable, the same as that of the water. The only time when this was not so was when comparisons at the temperature of 44° F. were read. Then the air temperature varied from 46° to 50° F. The water was constantly stirred while the thermometers were not being read.

The order in which the thermometers were read were Baudin 6131, then the Cassellas; Baudin 6131, then the A's and B's, and Baudin 6131 again. The mean of the 1st and 2d reading of Baudin 6131 was taken to compare with the Cassellas, and the mean of the 2d and 3d to compare with the A's and B's. The thermometer readings were made with a microscope, the micrometer comb-scale being used to estimate the revolutions and tenths on the mercury, the graduation preceding and the one following it. The time required to make one series of readings on all the thermometers was about five minutes. Cassella 21472 was close to Baudin 6131 in the tank. Series of readings were made at intervals of five minutes. Four series were usually made at each temperature.

The freezing points of all the thermometers were determined before and after the comparisons made in April and May. The means of all the observed freezing points after December 25, 1878, are used for the *a* corrections, except for Baudin's 6131, its *a* correction having been changed by boiling. The corrections determined at the time the comparisons were made were used as the *a* corrections at those times for Baudin 6131.

*Readings of Casella thermometers.*

HORIZONTAL IN MELTING ICE.

| Date. | No. of results. | 21472. | 21473. | 21474. | 21475. | 21476. |
|---|---|---|---|---|---|---|
| | | ° | ° | ° | ° | ° |
| December 26, 1878 | 12 | 32.14 | 32.09 | 32.11 | 32.07 | 32.12 |
| December 30, 1878 | 8 | .12 | ........ | ........ | ........ | ........ |
| January 18, 1879 | 4 | .12 | 32.05 | ........ | 32.05 | ........ |
| February 3, 1879 | 4 | .08 | .04 | ........ | .03 | ........ |
| February 5, 1879 | 4 | .10 | .03 | ........ | .05 | ........ |
| April 9, 1879 | 4 | .12 | ........ | 32.04 | ........ | 32.09 |
| April 12, 1879 | 4 | .12 | ........ | .04 | ........ | .08 |
| May 14, 1879 | 4 | .10 | ........ | .03 | ........ | .04 |
| May 16, 1879 | 4 | .09 | ........ | .03 | ........ | .05 |
| **Means** | ........ | 32.11 | 32.05 | 32.05 | 32.05 | 32.08 |
| *a* Corrections | ........ | −0.11 | −0.05 | −0.05 | −0.05 | −0.08 |

*Thermometers of Clarke yards.*

HORIZONTAL IN MELTING ICE.

| Date. | No. of results. | $A_1$. | $A_2$. | $A_3$. | $A_4$. | $B_1$. | $B_2$. | $B_3$. | $B_4$. |
|---|---|---|---|---|---|---|---|---|---|
| | | ° | ° | ° | ° | ° | ° | ° | ° |
| January 17, 1879 | 4 | ........ | 32.46 | 32.43 | 32.40 | ........ | ........ | ........ | ........ |
| January 18, 1879 | 4 | 32.61 | .50 | .44 | .40 | ........ | ........ | ........ | ........ |
| February 3, 1879 | 6 | .58 | .46 | .40 | .37 | ........ | ........ | ........ | ........ |
| February 5, 1879 | 4 | .58 | .47 | .43 | .41 | ........ | ........ | ........ | ........ |
| April 9, 1879 | 4 | .52 | .40 | .36 | .32 | 32.43 | 32.27 | 32.51 | 32.49 |
| April 12, 1879 | 4 | .57 | .46 | .36 | .33 | .44 | .28 | .49 | .49 |
| May 14, 1879 | 4 | .56 | .44 | .41 | .34 | .42 | .29 | .48 | .51 |
| May 16, 1879 | 4 | .57 | .45 | .40 | .35 | .38 | .28 | .48 | .49 |
| **Means** | ........ | 32.57 | 32.45 | 32.40 | 32.36 | 32.42 | 32.28 | 32.49 | 32.50 |
| *a* Corrections | ........ | −0.57 | −0.45 | −0.40 | −0.36 | −0.42 | −0.28 | −0.49 | −0.50 |

*a* Correction: Mean of $A_1$, $A_2$, $A_3$, $A_4$ = −0°.44. Mean of $B_1$, $B_2$, $B_3$, $B_4$ = −0°.42.

In the latter part of January 1879, Casella 21472 was compared with Casella 21473, 21475, $A_1$, $A_2$, $A_3$, $A_4$, and Baudin 6130. These comparisons are used to determine the corrections of Casella 21473 and 21475, taking Casella 21472 as the standard. The corrections of Casella 21472 are derived from the April and May comparisons with Baudin 6131, as are also the corrections of Casella 21474, 21476, and $B_1$, $B_2$, $B_3$, $B_4$. The corrections of $A_1$, $A_2$, $A_3$, $A_4$ are derived from the means of the results obtained from the

April and May comparisons with Baudin 6131, as the standard, and the January comparisons with Casella 21472 taken as the standard.

The following table gives the (*b*) correction of Cassella 21472 as determined in different ways. The corrections are derived from the comparisons with Baudin 6130 and Baudin 6131, calibration and other corrections being applied, from comparisons with $A_1$, $A_2$, $A_3$, $A_4$, and $B_1$, $B_2$, $B_3$, $B_4$, applying Lieutenant-Colonel Clarke's corrections to the means of both sets of thermometers, and from the corrections of this thermometer, furnished by Kew Observatory, England, and by Prof. H. Ste. Claire Deville, of Paris.

*Table of b corrections of Casella 21472, as derived from comparison with different thermometers.*

THERMOMETER HORIZONTAL.

| Bandin 6131. | | Mean of $A_1, A_2, A_3, A_4$. | Mean of $B_1, B_2, B_3, B_4$. | Bandin 6130. | | Kew Observatory, England. | | Ste. Claire Deville. | |
|---|---|---|---|---|---|---|---|---|---|
| *Temp. F.* | *b cor.* | *b cor.* | *b cor.* | *Temp. F.* | *b cor.* | *Temp. F.* | *b cor.* | *Temp. F.* | *b cor.* |
| ° | ° | ° | ° | ° | ° | ° | ° | ° | ° |
| 32 | 0.00 | 0.00 | 0.00 | 32 | 0.00 | 32 | 0.0 | .......... | ...... |
| .......... | .......... | .......... | .......... | .......... | .......... | 35 | 0.0 | .......... | ...... |
| .......... | .......... | .......... | .......... | 39.8 | +0.02 | 40 | 0.0 | .......... | ...... |
| 44.1 | +0.05 | .......... | .......... | .......... | .......... | 45 | +0.1 | .......... | ...... |
| 49.7 | +0.04 | −0.01 | +0.02 | 48.7 | +0.07 | 50 | +0.1 | .......... | ...... |
| 56.5 | +0.05 | 0.00 | 0.00 | 57.6 | +0.09 | 55 | 0.0 | .......... | ...... |
| 62.1 | +0.02 | −0.06 | −0.02 | .......... | .......... | 60 | 0.0 | 60.8 | ±0.02 |
| 68.0 | +0.02 | .......... | .......... | 66.7 | +0.07 | 65 | 0.0 | .......... | ...... |
| 75.6 | 0.00 | .......... | .......... | 75.8 | +0.08 | 70 | 0.0 | .......... | ...... |
| 84.4 | −0.03 | .......... | .......... | 84.7 | +0.06 | 75 | 0.0 | .......... | ...... |
| .......... | .......... | .......... | .......... | .......... | .......... | 80 | 0.0 | .......... | ...... |
| 92.9 | 0.00 | −0.07 | −0.05 | 93.8 | +0.06 | 85 | 0.0 | .......... | ...... |
| .......... | .......... | .......... | .......... | .......... | .......... | 90 | 0.0 | .......... | ...... |
| .......... | .......... | .......... | .......... | .......... | .......... | 85 | 0.0 | 91.4 | ±0.03 |

THERMOMETER HORIZONTAL.

*Table of b corrections of Casella 21472.*

[Taken from curves constructed from preceding table with the observed temperatures as abscissas and the corrections as ordinates.]

| Temperature, F. | Bandin 6131. | Bandin 6130. | Kew Observatory. | Mean of $A_1, A_2, A_3, A_4$. | Mean of $B_1, B_2, B_3, B_4$. | St. Claire Deville. |
|---|---|---|---|---|---|---|
| ° | ° | ° | ° | ° | ° | ° |
| 32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 37 | +0.02 | +0.01 | 0.00 | .......... | .......... | .......... |
| 42 | +0.04 | +0.04 | +0.05 | .......... | .......... | .......... |
| 47 | +0 04 | +0.06 | +0.11 | −0.01 | +0.02 | .......... |
| 52 | +0.04 | +0.08 | +0.05 | −0.01 | +0.01 | .......... |
| 57 | +0.05 | +0.09 | 0.00 | 0.00 | 0.00 | .......... |
| 62 | +0.02 | +0.08 | 0.00 | −0.06 | −0.02 | ±0.02 |
| 67 | +0.02 | +0.07 | 0.00 | −0.06 | −0.03 | .......... |
| 72 | +0.01 | +0.07 | 0.00 | .......... | .......... | .......... |
| 77 | −0.01 | +0.08 | 0.00 | .......... | .......... | .......... |
| 82 | −0.03 | +0.07 | 0.00 | .......... | .......... | .......... |
| 87 | −0.03 | +0.06 | 0.00 | −0.07 | −0.04 | .......... |
| 92 | −0.01 | +0.06 | 0.00 | −0.07 | −0.05 | ±0.03 |

Bandin 6131 is adopted as the standard.

In the latter part of December, 1878, cracks were noticed in the bulb of Bandin 6130. These gradually increased in size, and March 15, 1879, apparently admitted air into the bulb. Accordingly no results from this thermometer enter into the final corrections derived for the other thermometers.

The corrections of Casella 21472, 21474, 21476, $A_1$, $A_2$, $A_3$, $A_4$, and $B_1$, $B_2$, $B_3$, $B_4$, are derived from the comparisons made with it in April and May. The corrections of Casella 21473, 21475, and also of $A_1$, $A_2$, $A_3$, $A_4$, are derived from the comparisons made between them and Casella 21472 in January, using the corrections of Casella 21472 given by its comparison with Baudin 6131. These corrections are given in the preceding table. For the corrections of $A_1$, $A_2$, $A_3$, $A_4$, the means of the results given by the two series of comparisons is adopted. In the table of comparisons following, only the uncorrected readings of the thermometers are given, except for Baudin 6131 and Casella 21472.

*Thermometer comparisons, horizontal in water.*

| Date. | Reading of Baudin 6131. | $a+b$ corrections of Baudin 6131. | Corrected reading of Baudin 6131. | Corrected reading of Baudin 6131. | Readings uncorrected. | | | Corrected reading of Baudin 6131. | Readings uncorrected. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | 21472. | 21474. | 21476. | | $A_1, A_2, A_3, A_4$ | $B_1, B_2, B_3, B_4$ |
| | *Cent.* ° | *Cent.* ° | *Cent.* ° | *Fahr.* ° | ° | ° | ° | *Fahr.* ° | ° | ° |
| May 14, 15, and 16, 1879 | *0.252 | − 0.252 | 0.000 | 32.00 | 32.11 | 32.05 | 32.06 | 32.00 | 32.44 | 32.42 |
| May 16, 1879 | 6.950 | − 0.208 | 6.742 | 44.14 | 44.20 | 44.11 | 44.17 | 44.13 | 44.45 | 44.43 |
| May 16, 1879 | 10.028 | − 0.170 | 9.858 | 49.74 | 49.81 | 49.75 | 49.79 | 49.74 | 50.06 | 50.02 |
| May 16, 1879 | 13.755 | − 0.153 | 13.602 | 56.48 | 56.54 | 56.47 | 56.52 | 56.48 | 56.74 | 56.72 |
| May 15, 1879 | 16.814 | − 0.110 | 16.704 | 62.07 | 62.16 | 62.16 | 62.14 | 62.07 | 62.35 | 62.36 |
| May 15, 1879 | 20.042 | − 0.045 | 19.997 | 67.99 | 68.08 | 68.03 | 68.03 | 67.99 | 68.24 | 68.27 |
| April 14, 1879 | Baudin 6131 boiled. | | | | | | | | | |
| April 9 and 12, 1879 | *0.188 | − 0.188 | 0.000 | 32.00 | ........ | ........ | ........ | 32.00 | ........ | ........ |
| April 11, 1879 | 24.184 | + 0.039 | 24.223 | 75.60 | 75.71 | 75.66 | 75.69 | 75.60 | 75.89 | 75.92 |
| April 9 and 11, 1879 | 29.024 | + 0.062 | 29.086 | 84.35 | 84.49 | 84.44 | 84.50 | 84.35 | 84.65 | 84.67 |
| April 9 and 11, 1879 | 33.722 | + 0.097 | 33.819 | 92.88 | 92.99 | 92.94 | 92.96 | 92.83 | 93.07 | 93.07 |

*Thermometer comparisons, horizontal in water.*

| Date. | Reading of Casella 21472. | $a+b$ corrections of Casella 21472. | Corrected reading of Casella 21472. | Readings uncorrected. | | Corrected reading of Casella 21472. | Readings uncorrected of $A_1, A_2, A_3, A_4$ |
|---|---|---|---|---|---|---|---|
| | | | | 21473. | 21475. | | |
| | *Fahr.* ° | *Fahr.* ° | ° | ° | ° | ° | ° |
| | *32.11 | − 0.11 | 32.00 | 32.05 | 32.05 | 32.00 | 32.44 |
| January 29, 1879 | 39.91 | − 0.08 | 39.83 | 39.84 | 39.83 | 39.84 | 40.22 |
| January 27, 28, and 29, 1879 | 48.72 | − 0.07 | 48.65 | 48.66 | 48.68 | 48.65 | 48.98 |
| January 28 and 30, 1879 | 57.61 | − 0.06 | 57.55 | 57.53 | 57.56 | 57.55 | 57.82 |
| January 28 and 30, 1879 | 66.74 | − 0.09 | 66.65 | 66.64 | 66.68 | 66.66 | 66.93 |
| January 28 and 30, 1879 | 75.82 | − 0.11 | 75.71 | 75.74 | 75.77 | 75.72 | 76.01 |
| January 30, 1879 | 84.78 | − 0.14 | 84.64 | 84.72 | 84.77 | 84.64 | 84.94 |
| January 30, 1879 | 93.78 | − 0.12 | 93.66 | 93.71 | 93.74 | 93.64 | 93.87 |

* These readings made in melting ice.

From these tables of comparisons the following tables of *a* + *b* corrections of Casella 21472, 21473, 21474, 21475, 21476, $A_1$, $A_2$, $A_3$, $A_4$, and $B_1$, $B_2$, $B_3$, $B_4$, are made.

*a* + *b corrections*, *May*, 1879.

| Temperature, Fahr. | *a* + *b* correction of 21472. | *a* + *b* correction of 21474. | *a* + *b* correction of 21476. | *a* + *b* corrections of $A_1$, $A_2$, $A_3$, $A_4$. | *a* + *b* corrections of $B_1$, $B_2$, $B_3$, $B_4$. |
|---|---|---|---|---|---|
| ° | ° | ° | ° | ° | ° |
| 32.00 | − 0.11 | − 0.05 | − 0.08 | − 0.44 | − 0.42 |
| 44.1 | − 0.06 | + 0.03 | − 0.03 | − 0.32 | − 0.30 |
| 49.7 | − 0.07 | − 0.01 | − 0.05 | − 0.32 | − 0.28 |
| 56.5 | − 0.06 | + 0.01 | − 0.04 | − 0.26 | − 0.24 |
| 62.1 | − 0.09 | − 0.05 | − 0.07 | − 0.28 | − 0.29 |
| 68.0 | − 0.09 | − 0.04 | − 0.04 | − 0.25 | − 0.28 |
| 75.6 | − 0.11 | − 0.06 | − 0.09 | − 0.29 | − 0.32 |
| 84.4 | − 0.14 | − 0.09 | − 0.15 | − 0.30 | − 0.32 |
| 92.9 | − 0.11 | − 0.06 | − 0.10 | − 0.24 | − 0.24 |

*a* + *b corrections*, *January*, 1879.

| Temperature, Fahr. | *a* + *b* correction of 21473. | *a* + *b* correction of 21475. | *a* + *b* corrections of $A_1$, $A_2$, $A_3$, $A_4$. |
|---|---|---|---|
| ° | ° | ° | ° |
| 32.00 | − 0.05 | − 0.05 | − 0.44 |
| 39.9 | − 0.01 | 0.00 | − 0.38 |
| 48.2 | − 0.01 | − 0.03 | − 0.33 |
| 57.6 | + 0.02 | − 0.01 | − 0.27 |
| 66.7 | + 0.01 | − 0.03 | − 0.27 |
| 75.8 | − 0.03 | − 0.06 | − 0.29 |
| 84.8 | − 0.08 | − 0.13 | − 0.30 |
| 93.8 | − 0.05 | − 0.08 | − 0.28 |

From these curves of the *b* corrections were made. From the plotted curves the following table of *b* corrections is taken for Casella Nos. 21472, 21473, 21474, 21475, 21476, and for the means of $A_1$, $A_2$, $A_3$, $A_4$, and $B_1$, $B_2$, $B_3$, $B_4$, the corrections of $A_1$, $A_2$, $A_3$, $A_4$ being the means taken from two curves.

### THERMOMETERS HORIZONTAL, MAY, 1879.

*Table of b corrections.*

[Quantities to be applied to the scale readings; when + to be added. when — to be subtracted.]

DEPENDING ON BAUDIN'S 6131

| Temperature, Fahr. | 21472. | 21473. | 21474. | 21475. | 21476. | Mean of $A_1$, $A_2$, $A_3$, $A_4$ | Mean of $B_1$, $B_2$, $B_3$, $B_4$ |
|---|---|---|---|---|---|---|---|
| ° | ° | ° | ° | ° | ° | ° | ° |
| 32 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 37 | +0.02 | +0.02 | +0.04 | +0.04 | +0.02 | +0.04 | +0.05 |
| 42 | +0.04 | +0.04 | +0.07 | +0.04 | +0.04 | +0.10 | +0.10 |
| 47 | +0.04 | +0.04 | +0.06 | +0.02 | +0.04 | +0.12 | +0.14 |
| 52 | +0.04 | +0.05 | +0.04 | +0.03 | +0.03 | +0.14 | +0.15 |
| 57 | +0.05 | +0.07 | +0.06 | +0.04 | +0.04 | +0.18 | +0.18 |
| 62 | +0.02 | +0.07 | 0.00 | +0.03 | +0.01 | +0.17 | +0.13 |
| 67 | +0.02 | +0.06 | +0.01 | +0.02 | +0.03 | +0.18 | +0.14 |
| 72 | +0.01 | +0.04 | +0.01 | +0.00 | +0.02 | +0.17 | +0.13 |
| 77 | −0.01 | +0.01 | −0.02 | −0.02 | −0.02 | +9.15 | +0.10 |
| 82 | −0.03 | −0.02 | −0.04 | −0.07 | −0.06 | +0.14 | +0.09 |
| 87 | −0.03 | −0.03 | −0.04 | −0.07 | −0.06 | +0.15 | +0.12 |
| 92 | −0.01 | −0.01 | −0.02 | −0.05 | −0.03 | +0.19 | +0.17 |

To find the total or *a* + *b*, corrections of these thermometers at any time, add to the above corrections the correction of the thermometer at freezing point for that time. In case there is no observation of the freezing point at the time the total correction is required, use an interpolated value of the correction at freezing point, according to the time, from the nearest two determinations, one before and one after the time for which the correction is wanted.

The following table contains all the determinations of the freezing points of these thermometers that have been made.

THERMOMETERS HORIZONTAL, FAHR.

*Table of a corrections.*

[Quantities to be applied to scale readings in melting ice.]

| Date. | 21472. | 21473. | 21474. | 21475 | 21476. | Mean of $A_1, A_2, A_3, A_4$ | Mean of $B_1, B_2, B_3, B_4$ |
|---|---|---|---|---|---|---|---|
| | ° | ° | ° | ° | ° | ° | ° |
| Lieutenant-Colonel Clarke, April 15, 1874 | ...... | ...... | ...... | ...... | ...... | −0.30 | −0.28 |
| Lieutenant-Colonel Clarke, May 2, 1874 | ...... | ...... | ...... | ...... | ...... | −0.28 | −0.24 |
| Kew Observatory, England, January, 1875 | −0.0 | +0.1 | +0.1 | +0.1 | +0.1 | .......... | .......... |
| Detroit, Mich., March, 1875 | +0.06 | +0.13 | +0.14 | +0.15 | +0.13 | −0.37 | −0.34 |
| Detroit, Mich., December, 1875 | −0.01 | +0.08 | +0.06 | +0.07 | +0.08 | −0.40 | −0.38 |
| Ste. Claire Deville, Paris, September, 1876 | 0.00 | ...... | ...... | ...... | ...... | .......... | .......... |
| Detroit, Mich., December, 1876 | −0.04 | ...... | ...... | ...... | ...... | .......... | .......... |
| Detroit, Mich., May, 1879 | −0.11 | −0.05 | −0.05 | −0.05 | −0.08 | −0.44 | −0.42 |

The difference in the reading of the Casella thermometers, horizontal and vertical, in melting ice, is 0°.04 F., the readings being greater when horizontal.

The following table contains the *b* corrections of the Geissler thermometers, deduced from comparisons made with Casella 21472, March, 1877, and also the *a* corrections, or the corrections at freezing point, in January, 1877, and January, 1879. The corrections of Casella 21472 used in this reduction are those determined from its comparison with Baudin 6131. As the comparisons of the Geissler thermometer were made with Casella 21472 vertically, a system of corrections of 21472 was used, differing from the foregoing by a constant 0°.04, which is the difference between its readings horizontally and vertically in melting ice.

*Table of b corrections of Geissler thermometers.*

VERTICAL.

DEPENDING ON BAUDIN 6131.

| Date. | Temp. | *No. 1. | No. 2. | No. 3. | No. 4. |
|---|---|---|---|---|---|
| | ° | ° | ° | ° | ° |
| March, 1877 | 32.0 | 0.00 | 0.00 | 0.00 | 0.00 |
| | 40.5 | −0.06 | +0.04 | +0.06 | −0.01 |
| | 50.0 | −0.19 | +0.01 | 0.00 | −0.05 |
| | 60.2 | −0.33 | −0.05 | −0.10 | −0.13 |
| | 70.2 | −0.42 | −0.14 | −0.15 | −0.15 |
| | 79.8 | −0.56 | −0.27 | −0.23 | −0.20 |

*August, 1878, Geissler No. 1 was returned from the field with the graduated scale loose; it was refastened. On this account an interpolated value of the *a* correction for No. 1 would not be proper for any time when the corrections are required between January, 1877, and January, 1879. The freezing point of No. 1 probably changed by about the same amount as the others, and a rate of change equal to the mean change of the other three thermometers might be used to determine its *a* correction between January, 1877, and January, 1879.

*a Corrections.*

THERMOMETERS HORIZONTAL IN MELTING ICE.

| Date. | Temp. | No. 1. | No. 2. | No. 3. | No. 4. |
|---|---|---|---|---|---|
| | ° | ° | ° | ° | ° |
| January, 1877 | 32.0 | −0.22 | −0.13 | +0.66 | −0.18 |
| January, 1879 | 32.0 | −0.55 | −0.40 | +0.50 | −0.36 |

Very respectfully, your obedient servant,

THOMAS RUSSELL,
*Assistant Engineer, United States Lake Survey.*

General C. B. COMSTOCK,
*United States Engineers.*

## APPENDIX No. 9.

## WATER-LEVEL REDUCTIONS.

### REPORT OF MR. A. R. FLINT, ASSISTANT ENGINEER.

OFFICE OF UNITED STATES LAKE SURVEY,
*Detroit, May* 31, 1879.

SIR: I have the honor to submit the following report on the reduction of water-level observations made since June 1, 1878.

Tri-daily observations have been made at ten stations, viz: Marquette and Sault Ste. Marie, on Lake Superior; Milwaukee and Escanaba, on Lake Michigan; Port Austin, on Lake Huron; Detroit, on Detroit River; Cleveland and Erie, on Lake Erie; Charlotte and Sacket's Harbor, on Lake Ontario.

### AT MARQUETTE,

Escanaba, and Port Austin the observations have not been continuous during the winter months, owing to ice and other obstructions.

The reductions have been made in the same manner as in previous years, and the plane of reference for each lake is unchanged. For details see Chief of Engineers' Report for 1876, Part III, page 80. The relative differences of elevation between the bench-marks and the gauge zeros and check points were determined during the year at each station, except Detroit and Port Austin; the check observations at these two stations indicate no change in zero of either gauge.

The following table gives the elevations of zero of gauge and check point above the respective planes of reference from determinations made in 1877 and 1878:

| Stations. | Zero of guage above plane of reference. | | Check point above plane of reference. | |
|---|---|---|---|---|
| | 1877. | 1878. | 1877. | 1878. |
| | *Feet.* | *Feet.* | *Feet.* | *Feet* |
| Charlotte | −0.58 | −0.65 | −0.58 | −0.58 |
| Sacket's Harbor | +0.18 | +0.15 | +1.33 | +1.31 |
| Cleveland | +1.54 | +1.54 | +0.96 | +0.96 |
| Erie | +0.57 | +0.64 | +1.01 | +1.02 |
| Detroit | +2.00 | ........ | +1.27 | ........ |
| Milwaukee | +1.26 | +1.26 | +1.86 | +1.86 |
| Escanaba | +0.80 | +0.83 | +1.16 | +1.17 |
| Port Austin | +6.19 | ........ | −1.23 | ........ |
| Sault Ste. Marie | +0.74 | +0.74 | ........ | ........ |
| Marquette | +2.07 | +2.03 | +2.12 | +2.12 |

At Charlotte the zero of the gauge and the check point are below the plane of reference; at Port Austin the check point is below the plane of reference.

The location of gauges and check points remain the same as last year.

Bench-mark No. 3 at Erie has been washed away.

Self-registering gauges have been maintained at Marquette, Milwaukee, and Port Austin.

The following table and graphical curves for the year 1878–'79 are continuations of those in Appendix G of the last annual report.

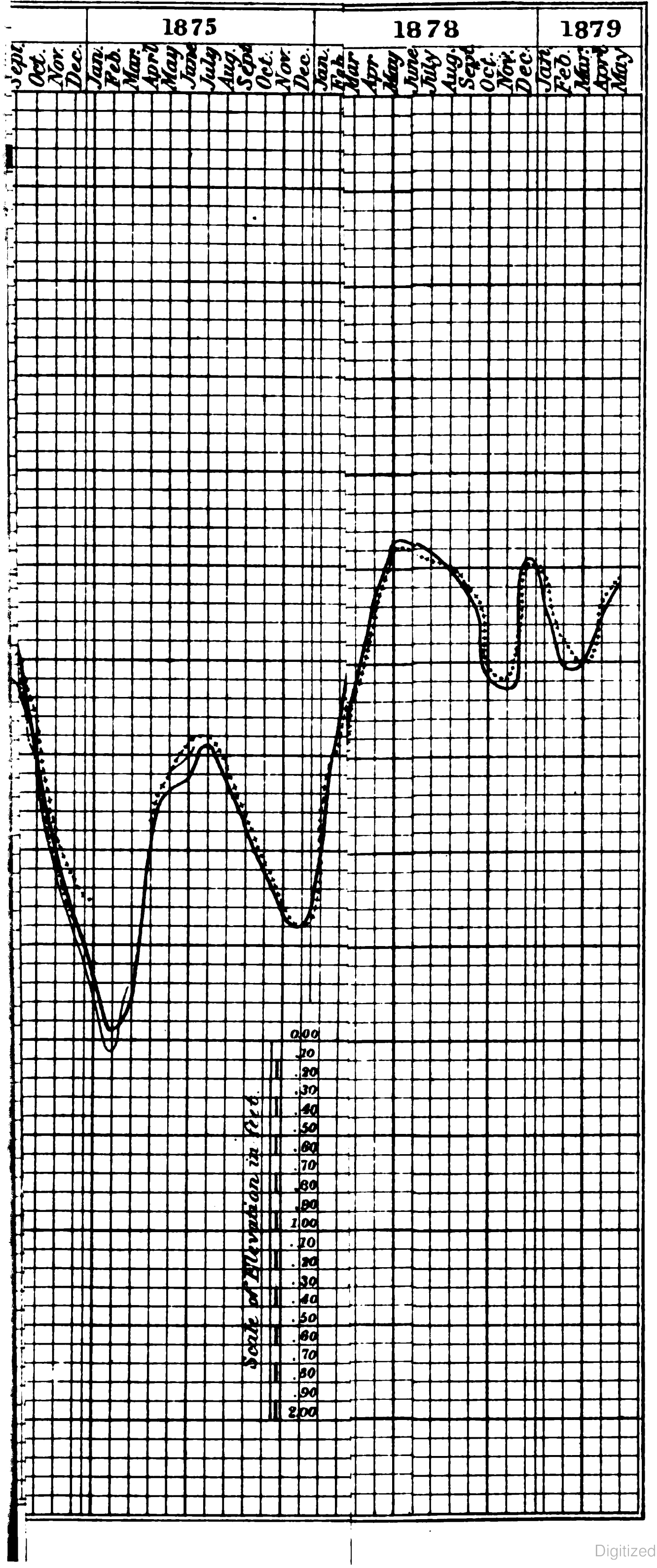
Reports Nos. 291, 385, 466, 816, 832, 970, and 1011 have been used in preparing this report.

Respectfully submitted,

A. R. FLINT,
*Assistant Engineer.*

General C. B. COMSTOCK.

# Plate I.


1875
1878
1879
Sept.
Oct.
Nov.
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Jan.
Feb.
Mar.
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Mar.
April
May
Scale of Elevation in Feet.
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.80
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1.00
.10
.20
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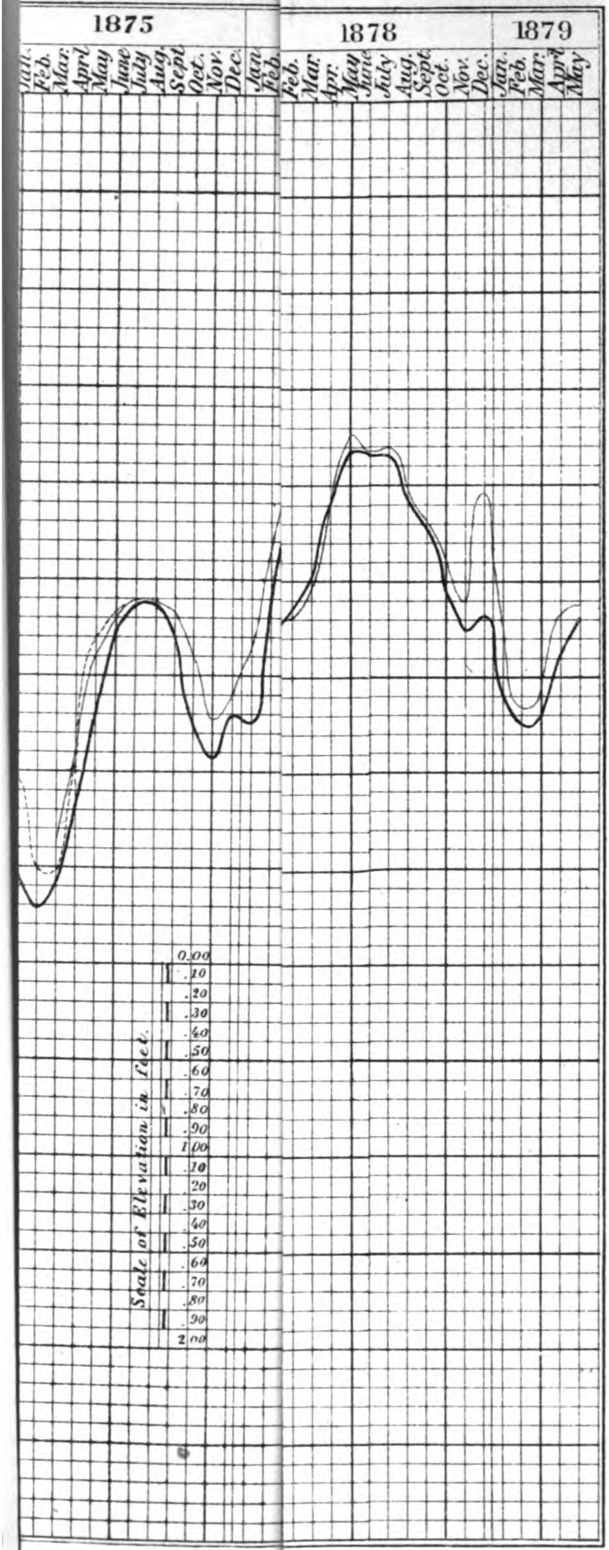
.90
2.00

Plate II.


1875
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Oct.
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1878
Feb.
Mar.
Apr.
May
June
July
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Oct.
Nov.
Dec.
1879
Jan.
Feb.
Mar.
April
May
Scale of Elevation in Feet.
0.00
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.40
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.60
.70
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.90
1.00
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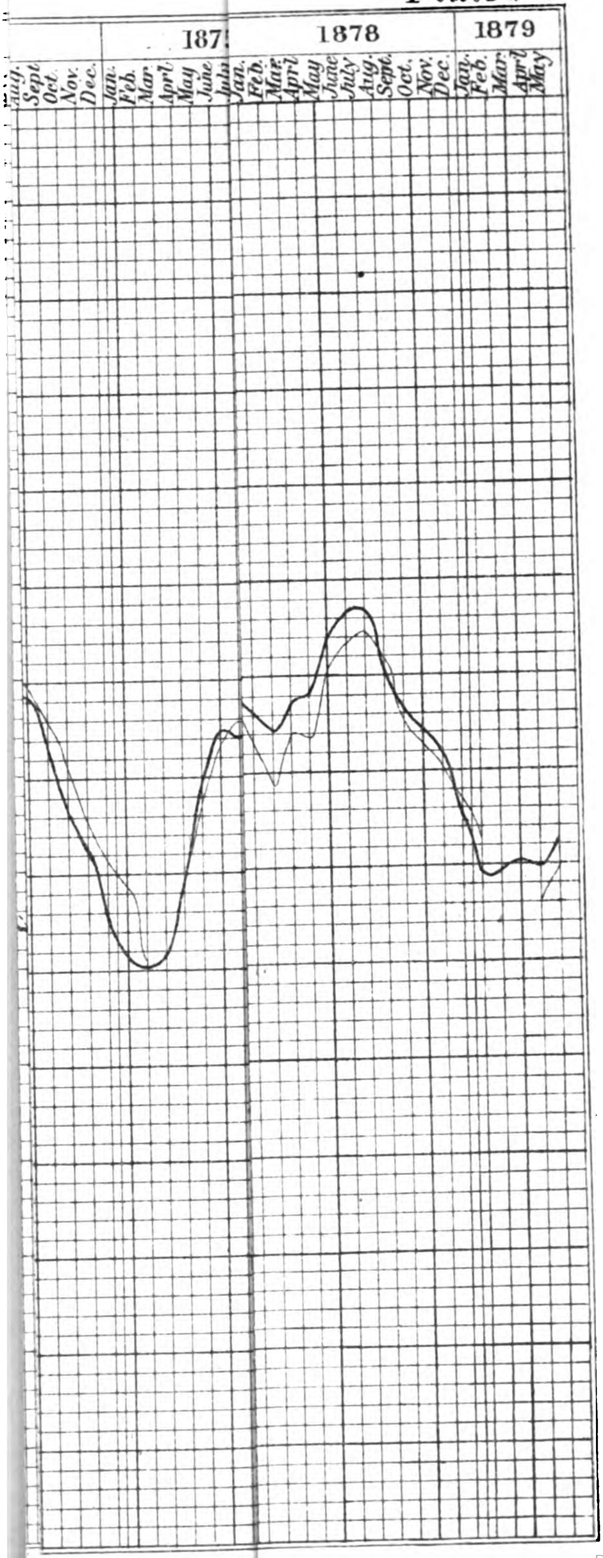
.80
.90
2.00

Plate III.


187
1878
1879
Sept.
Oct.
Nov.
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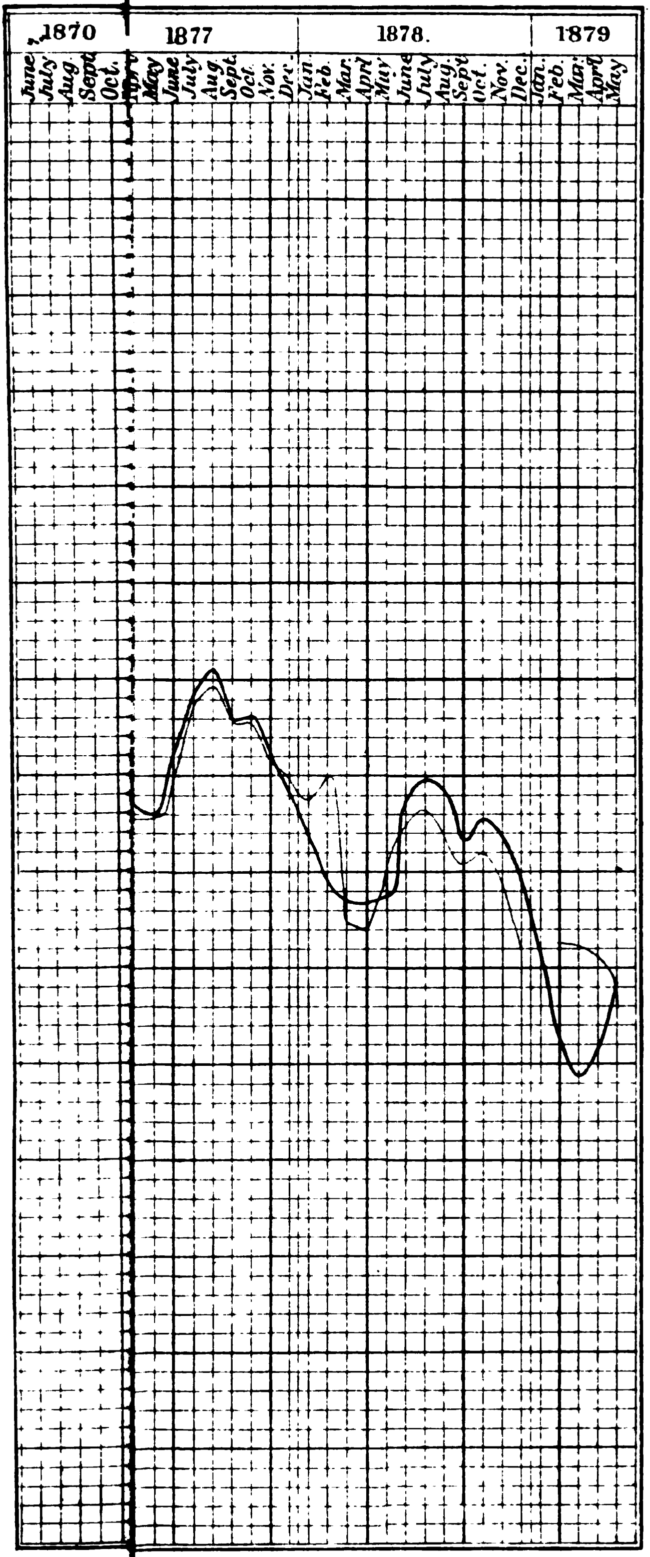
May


1876
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Dec.
Jan.
Feb.
Mar.
April
May

*Mean monthly water levels for the several stations, in feet and decimals, below the planes of reference.*

(Continuation of table in Appendix G, annual report for 1878.

| Stations. | 1878. | | | | | | | 1879. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | June. | July. | August. | September. | October. | November. | December. | January. | February. | March. | April. | May. |
| Charlotte | 1.88 | 1.92 | 2.02 | 2.17 | 2.60 | 2.63 | 1.95 | 2.18 | 2.52 | 2.50 | 2.24 | 2.08 |
| Sacket's Harbor | 1.93 | 1.96 | 1.98 | 2.13 | 2.51 | 2.58 | 2.00 | 2.06 | 2.86 | 2.50 | 2.19 | 2.05 |
| Cleveland | 1.34 | 1.34 | 1.58 | 1.71 | 2.06 | 2.26 | 2.18 | 2.60 | 2.74 | 2.71 | 2.35 | 2.20 |
| Erie | 1.32 | 1.30 | 1.54 | 1.68 | 1.91 | 2.11 | 1.54 | 2.21 | 2.65 | 2.56 | 2.17 | 2.12 |
| Detroit | 1.42 | 1.33 | 1.55 | 1.65 | 1.96 | 2.13 | 1.76 | 2.58 | 3.68 | 2.89 | 2.49 | 2.38 |
| Milwaukee | 2.16 | 2.15 | 2.47 | 2.67 | 2.78 | 2.91 | 3.23 | 3.54 | 3.53 | 3.49 | 3.50 | 3.37 |
| Escanaba | 2.24 | 2.18 | 2.43 | 2.62 | 2.65 | 2.94 | 3.15 | ...... | ...... | ...... | 3.51 | 3.38 |
| Port Austin | 2.34 | 2.27 | 2.41 | 2.73 | 2.86 | 2.96 | 3.14 | 3.36 | ...... | ...... | 3.70 | 3.51 |
| Sault Ste. Marie | 3.13 | 3.02 | 3.06 | 3.35 | 3.23 | 3.32 | 3.54 | 3.94 | 4.34 | 4.58 | 4.45 | 4.08 |
| Marquette | 3.25 | 3.18 | 3.30 | 3.47 | 3.40 | 3.60 | 3.92 | ...... | 3.86 | 3.56 | 3.95 | 4.31 |

## APPENDIX No. 10.

## RESULTS OF SAND WAVE AND SEDIMENT OBSERVATIONS.

### REPORT OF MR. J. B. JOHNSON, ASSISTANT ENGINEER.

DETROIT, MICH., *June* 30, 1879.

SIR: I have the honor to submit the following report of work done by the permanent party on the Mississippi River from March 10 to June 23, 1879:

The organization of the party was as follows: J. B. Johnson, assistant engineer; W. M. Childs, recorder; Edward Rickitts, leadsman; a cook, and four boatmen. Additional boatmen were employed when needed.

The party was organized near Peters Landing, Ark., on March 10, and was quartered on the United States survey boat Pioneer. The boat was allowed to drift down the river to a point immediately opposite Helena, on the Mississippi shore, where it arrived on the 11th.

### I.—CHARACTER OF WORK.

According to instructions received from Lieut. D. W. Lockwood, Corps of Engineers, the work of the party was to consist of—

1. The sounding of five lines across the river at Helena and five lines at Trotters (a landing 3 miles above Helena) every 15 days, or for every five-foot change of river surface, if such change should occur in less time.
2. Daily sediment observations.
3. Velocity measurements with mid-depth floats and determination of river slope.
4. Daily gauge-readings.

The soundings were to determine what relative changes, if any, occurred in the river bottom in the deep water at Trotters and in the shoal water at Helena, for varying stages of river surface.

The lines at Helena were sounded 9 times, and those at Trotters 8 times.

River discharge and river slope were to be determined on two days at highest water, and on two days at lowest water. These instructions were afterwards modified, and these determinations were ordered to be made every ten days.

Velocity measurements were taken and discharge computed on five days, lines 4 and 5 of the Helena sections being used for that purpose.

The river slope was found on 9 days, 5 of which correspond with the dates of river discharge determinations.

Gauge-readings and sediment observations were made daily.

Longitudinal lines, mostly in shoal water, were sounded on 16 days, between May 7 and June 17.

Bench marks were established in the vicinity of all water gauges and properly connected in duplicate with the precise bench-marks and reference points established by Assistant L. L. Wheeler.

## II.—METHODS.

1. *Soundings.*—The five lines to be sounded, both at Helena and at Trotters, were located in December, 1878. They were 100 meters apart at each place, except lines 3 and 4 of the Helena sections, which were 120 meters apart. They were marked by posts set a few meters from each bank, and these posts were located by Assistant Ockerson's triangulation. At Trotters, however, the Mississippi shore has a caving bank, and on March 12 these sounding stations were all gone. Several of Mr. Ockerson's triangulation stations had also been washed away by the January rise. To supply the necessary stations from which to observe the soundings and to relocate the stations at Trotters I found it necessary to retriangulate about 4 miles of the river. The length of the section lines at Trotters is 2,400 meters; at Helena they are 1,400 meters long. At Trotters, however, they cross Middle Bar, which is entirely covered only at flood stage. Stations were located on this bar on the several lines. Range poles about 30 feet high, having a small white flag, were set about 100 meters back of each sounding station.

Two instruments were used on shore to intersect on the sounding-boat, until it was found that one was sufficient. All soundings at high stage and those in the deepest water at Trotters at low stage were taken by allowing the boat to drift with the current down across the lines. In order to get the soundings properly spaced, when they were taken in this way an additional line was established by means of posts and ranges 50 meters above the first section line, and the boat flagged to its position on this line by the observer on shore. These downstream lines were made to be about 70 meters apart, so that successive soundings on each section-line were separated by that interval. At low stage the Helena sections and the shoal water at Trotters were sounded by pulling the boat directly across the river, keeping it on line, soundings being taken every half minute. This made the successive soundings about 35 meters apart. When sounding by downstream lines a flag was dropped in the boat at the instant the leadsman reached the range, he calling "tick," and the pointing taken and line read. When sounding across the river every minute sounding was flagged.

The lead-line was always read to tenths of a foot. It was carefully tested both before and after each set of soundings, it being thoroughly soaked at each testing. A 23-pound lead was used for all soundings after April 1.

For the Helena sections the readings on gauge 1 at the quarter-boat were taken, from which to determine elevation of river surface. This gauge was 250 meters above the first section line. At Trotters a temporary gauge was set on each side of the river on every day when those sections were sounded.

Two leads, with 100 feet of line attached to each, were lost on line 2 at Trotters on the first attempt to sound those sections. The bottom was full of trees which had recently caved into the river. The lead caught on these and it was found impossible to remove it or to break the line. It was not considered safe after that to sound lines 1 and 2 at Trotters within 300 meters of the Mississippi shore.

The shore-line at Trotters was run on June 11 to determine the extent of the caving there. It was found to have caved from 40 to 120 meters after Mr. Ockerson ran it in the December previous.

2. *Sediment observations.*—Specimens of water were taken daily from the surface and from a foot above the bottom, at points one-quarter and three-quarters of the distance across the river. The two surface specimens were put into one vessel, and the two bottom specimens in another. Arriving on shore each was thoroughly shaken and a given quantity measured out and put into jars marked "Surface" and "Bottom," respectively. When five days' specimens had been put into one set of jars they were allowed a week or more to settle. After the water had become quite clear it was siphoned off, and the sediment filtered. An ordinary filter-paper was used at first, but it was found to be not very reliable, and "Munktells" paper was used exclusively afterward. Two papers were made of exactly equal weight, the scales weighing readily to a milligramme, and the filtering done through both of them. Care was taken not to touch the papers with the hand in cutting and weighing, as the moisture absorbed by a momentary contact was quite sensible. The papers were usually dried by a slow fire in an open stove oven, sometimes in the sun. When thoroughly dry, they were carried at once to the scales and their difference of weight determined. This difference was taken as the weight of sediment. The two papers that belonged to a single specimen were then put together in a separate envelope and carefully laid away in the desk. Numerous subsequent weighings were made of each set of papers at intervals of several days, but these weights were not used in the final reduction, as the weight of sediment thus obtained was uniformly from 2 to 4 per cent. greater than the weight obtained immediately after drying.

The sediment work was done in a tent erected on shore for that purpose. The scales were mounted on a post set firmly in the ground, and entirely free from the tent floor.

It soon became apparent that the bottom specimens contained too much heavy sand, but it was not till April 8 that I found time to examine the matter thoroughly. The can furnished me for obtaining water from the bottom of the river was made of sheet-copper, cylindrical, 12 inches high, 4 inches in diameter. There were two valves, one at top and one 6 inches from the top, both opening up. A concentric ring of lead was molded upon the inside at bottom to sink it, leaving an opening 2¼ inches in diameter for the passage of water into and through the upper chamber, which was 4 inches in diameter. When this can would strike the bottom it would incline downstream, and the current would instantly force more or less of the sand from the bottom into the upper chamber, from which the specimen of water was taken.

It would seem that the requirements of a good sediment apparatus are—

1. That at any desired point it should contain within it a fair specimen of the water which then immediately surrounds it.

2. That while it remains at this point, the contents of the vessel should remain undisturbed.

3. That it should bring its contents securely to the surface.

To fulfill the first requirement, the vessel would have to be sunk empty and opened at the desired point, or else it must be open for its entire horizontal cross-section in sinking. The first is impracticable, from the great pressure. The second can be realized. If the passage for the water is not the *entire* cross-section of the retaining vessel, the water it contains is constantly a mixture of water from all depths above it, as was the case in the can above described. It was, however, a total failure in the second requirement, which made the can worthless.

On April 8, I attached a small tin can, called "test can," to the side of the copper can previously used, which I thought would fulfill all the essential conditions. It worked so satisfactorily, and proved so conclusively the worthlessness of the copper can, that I asked and received permission to have a permanent one made embodying the same principles. This *improved sediment-can* (Fig. I) was first used on April 30. The excellent results obtained by it attest its merits. The lids *a a* can be drawn together by greater or less force by increasing or diminishing the number of rubber bands on the open eyes *e e*. These bands were always loosened from one of the eyes when the can was not in use, in order not to weaken their elasticity.

Previous to April 25 the daily specimens of water were *measured* out; after that they were *weighed*. There is a practical difficulty in measuring out a given quantity of water which contains a sediment which settles rapidly, and obtain a fair sample of the mixture. When the water was weighed it was taken from a tin can, by an aperture ¼ inch above the bottom, while the water was kept in violent agitation.

3. *Velocity measurements.*—The methods used in this work were virtually those described in Humphrey's and Abbott's Report on the Missisippi River. Lines 4 and 5 of the Helena sections were selected on which to observe the floats. They were 100 meters apart. The two lines were sounded on the days when velocities were determined.

For computing the discharge, the cross-section was divided into one more parts than there were t stations, the points of division being at

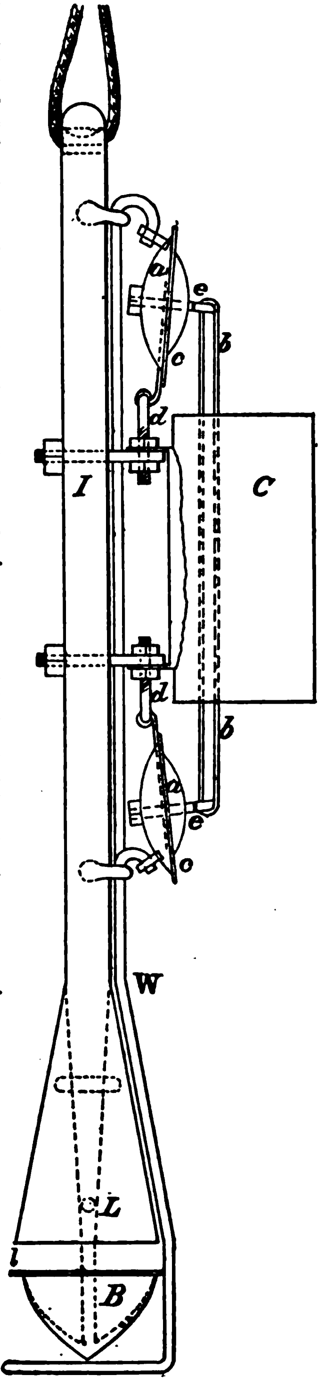

FIG. 1.

*C*, galvanized iron can; *I*, iron bar 1 inch square; *L*, lead; *B*, bottom cup; *l*, leather cover; *W*, springing wire; *a a*, galvanized iron lids; *e e*, open eyes; *b b*, rubber bands; *o o*, rubber packing; *d d*, adjustable hinges; scale, ¼; weight, 18 pounds; contents of can, 1.47 pints.

these stations. The mean of the mid-depth velocities at the two sides of a division was taken as the mid-depth velocity of that division. For the outside divisions the mean mid-depth velocity was taken as eight-tenths of that velocity at the first float-station from shore. The mean of the division areas on the two section lines was taken as the area of that division.

The submerged floats consisted of two tin cylinders, 15 inches high, concentrically fixed, the outer one 10 inches and the inner one 8 inches in diameter. This left an annular space of 1 inch in thickness between the cylinders. The water was allowed access to the lower 12 inch of this space, the upper 3 inches being closed and filled with air. The float would then barely sink of its own weight. A three-pound lead weight was fastened to cross-wires at the bottom. The suspending cord, which was woven cotton, 0.04 inch in diameter, was fastened to cross-wires at the center of the float. The air in the upper part of the float and the weight at bottom would strongly tend to maintain the float in a vertical position.

The surface floats were oblate ellipsoids, made of zinc, horizontal diameter 10 inches, vertical diameter 2¼ inches. A weight of three pounds submerged them to the center. They carried small flags at top.

4. *River slope.*—This was usually obtained by 4 hours' simultaneous readings (reading taken every 15 minutes) on gauges 4, 1, and 5, placed respectively at triangulation station 37, 1,110 meters below, at the quarter boat 620 meters above, and at triangulation station 33, 1,960 meters above, a point midway between the section lines used for velocity measurements. The gauges were carefully connected in duplicate with their corresponding bench-marks on the days when river slope was determined. It is thought the error in the elevation of the zero of the gauge was never more that 0.01 foot.

5. *Daily gauge-readings.*—Gauge 1 was read daily at 7 a. m., 12 m., and at 6 p. m.

All gauges were boards painted white and graduated in black to half-tenths of a foot. They were securely fastened to stakes driven firmly into the ground, and were frequently tested for elevation of zero.

## III.—RESULTS.

1. *Soundings on section lines.*—The results of all section-line soundings are shown on the combined profile sheets. No great changes occurred at either Trotters or Helena. The small and apparently erratic changes shown on the Helena sections could only be satisfactorily explained by supposing the bottom of the river there to consist of waves, whose axes bore a certain angle to the section lines, and that these waves had a motion downstream. This proved to be the case.

2. *Soundings on longitudinal lines.*—On May 7 I commenced sounding longitudinal lines from a point 2,000 meters above the Helena sections to a point 1,000 meters below them. Two such lines would be sounded on the same day, near the middle of the river, from 100 to 300 meters apart, and repeated every three to five days. The boat was allowed to drift with the current, the lead to remain near the bottom, and soundings taken every 15 seconds. This made the soundings from 20 to 25 meters apart. A flag was shown in the boat at every minute sounding, and the position of the leadsman located by two instruments favorably placed on shore. The soundings were then plotted in both plan and profile. Effort was made to have the two lines of successive soundings to coincide, as nearly as possible, with those of previous soundings. All lines in plan were copied on a sheet of tracing linen. Whenever two were found to coincide in position their profiles at this point could be compared. A line was drawn from triangulation station 35 at right angles to the current, and called a *reference line*, on which to arrange the profiles for comparison. If the axes of the waves were right lines and parallel to this reference line, profiles of different dates, when arranged on this line, might be compared for motion of wave, though they should not coincide in plan. Unfortunately, neither of these conditions seemed to be fulfilled, so that only those lines and parts of lines which very nearly coincided in plan could be safely used to determine the motion of the waves. The prominent waves shown by the first day's soundings were numbered; afterward portions of one or both lines would usually coincide closely with some previous line, and by comparing these parts of the profiles the waves here could be clearly indentified, provided too long a time had not elapsed between the soundings. The remaining waves on the new line could then be safely numbered from their relation to the waves that had been thus identified. Longitudinal lines were sounded over as nearly as possible the same portion of the river on May 7, 9, 13, 16, 19, 26, 30, June 4, 9, 13, and 17. On plate I is shown a portion of seven of these lines in plan and section. Waves 9, 10, 11, 13, and 17 had been continuously identified, with the exception of wave 9 on the last three lines, which is somewhat uncertain. It may be an entirely new wave. The datum planes of these sections have been arranged on the reference-line, according to the date of the soundings. Dotted

# PLATE I.

lines are drawn joining the several positions of the same wave, which lines show the rate of movement of the waves downstream.

From all the observations that have been made the following facts may be stated concerning—

*Sand waves at Helena.*

Average length of waves from crest to crest, about 100 meters.
Extreme length of waves from crest to crest, about 150 meters.
Average height of waves from crest to valley, about 5 feet.
Extreme height of waves from crest to valley, about 8 feet.
Average velocity of motion of crest, 5.41 meters per day.

These results were obtained in a depth of water varying from 13 to 30 feet. The stage of river varied from 12 to 18 feet above low-water at Helena.

The waves decrease in size for a falling river and *vice versa*. Their rate of motion down stream is a function of the velocity of the water. They do not extend from bank to bank at Helena, but disappear about 200 meters from each shore, covering about 1,000 meters of the cross-section of the river.

3. *Sediment observations.*—The following table contains the results of the sediment observations. It will be noticed that the ratio of the bottom to surface proportions of sediment vary almost uniformly after the improved apparatus was used.

*Result of sediment observations at Helena*, 1879.

[In this table omissions marked thus (*) were made because no confidence is placed in the results on account of the poor apparatus for obtaining the bottom specimens.]

| Date of observation. | Kind of specimen. | Mean depth of bottom in feet. | Weight of water in milligrammes. | Weight of sediment in milligrammes. | Proportion of sediment to water by weight. | Ratio of bottom to surface proportions. | Percentage of particles by diameters in inches. | | | | | | Mean velocity of current in feet per second. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 0.0 to .001. | .001 to .002. | .002 to .005. | 0.0 to .005. | .005 to .01. | .01 to .03. | | |
| March 1 to 10 | Surface | .... | 447, 600 | 159 | $\frac{1}{2815}$ (.000355) | .... | 80 | 10 | 10 | .... | .... | .... | .... | |
| | Bottom | 23 | 447, 600 | (*) | .... | .... | .... | .... | .... | .... | .... | .... | .... | |
| March 11 to 15 | Surface | .... | 559, 500 | 170 | $\frac{1}{3291}$ (.000304) | .... | 70 | 10 | 20 | .... | .... | .... | .... | |
| | Bottom | 29 | 559, 500 | (*) | .... | .... | .... | .... | .... | .... | .... | .... | .... | |
| March 16 to 20 | Surface | .... | 559, 500 | 281 | $\frac{1}{1991}$ (.000502) | .... | 80 | 10 | 10 | .... | .... | .... | .... | |
| | Bottom | 28 | 559, 500 | (*) | .... | .... | .... | .... | .... | .... | .... | .... | .... | |
| March 21 to 25 | Surface | .... | 559, 500 | 311 | $\frac{1}{1799}$ (.000556) | .... | 70 | 15 | 15 | .... | .... | .... | .... | |
| | Bottom | 36 | 559, 500 | (*) | .... | .... | .... | .... | .... | .... | .... | .... | .... | |
| March 26 to 30 | Surface | .... | 559, 500 | 254 | $\frac{1}{2203}$ (.000454) | .... | 70 | 10 | 20 | .... | .... | .... | .... | |
| | Bottom | 37 | 559, 500 | (*) | .... | .... | .... | .... | .... | .... | .... | .... | .... | |
| March 31 to April 4 | Surface | .... | 559, 500 | 296 | $\frac{1}{1890}$ (.000529) | .... | 75 | 15 | 10 | .... | .... | .... | 4. 26 | Velocity determined April 4. |
| | Bottom | 40 | 559, 500 | (*) | .... | .... | .... | .... | .... | .... | .... | .... | | |
| April 5 to 9 | Surface | .... | 559, 500 | 236 | $\frac{1}{2371}$ (.000422) | .... | 80 | 10 | 10 | .... | .... | .... | .... | |
| | Bottom | 40 | 559, 500 | (*) | .... | .... | .... | .... | .... | .... | .... | .... | .... | |
| April 10 to 14 | Surface | .... | 559, 500 | 220 | $\frac{1}{2543}$ (.000393) | 1. 90 | 70 | 10 | 10 | .... | 10 | .... | .... | From April 8 to April 29 the bottom specimens were taken from a "test can" attached to the former sediment can. |
| April 8 to 12 | Bottom | 37 | 559, 500 | 418 | $\frac{1}{1338}$ (.000747) | | .... | .... | .... | 80 | 10 | 10 | .... | |
| April 15 to 19 | Surface | .... | 559, 500 | 431 | $\frac{1}{1298}$ (.000770) | .98 | 70 | 10 | 10 | .... | 10 | .... | .... | |
| April 13 to 17 | Bottom | 38 | 559, 500 | 420 | $\frac{1}{1332}$ (.000751) | | .... | .... | .... | 80 | 12 | 8 | .... | |
| April 18 to 19 | Bottom | .... | 223, 800 | 314 | $\frac{1}{713}$ (.001403) | | .... | .... | .... | 80 | 10 | 10 | .... | |
| April 20 to 24 | Surface | .... | 559, 500 | 735 | $\frac{1}{761}$ (.001314) | 1. 13 | 80 | 10 | 10 | .... | .... | .... | .... | |
| | Bottom | 35 | 559, 500 | 829 | $\frac{1}{675}$ (.001482) | | .... | .... | .... | 85 | 8 | 7 | .... | |
| April 25 to 29 | Surface | .... | 764, 280 | 620 | $\frac{1}{1233}$ (.000811) | 2. 34 | 70 | 10 | 10 | .... | 10 | .... | .... | Previous to April 25 the specimens of water were measured out. After that they were weighed. |
| | Bottom | 30 | 378, 480 | 718 | $\frac{1}{527}$ (.001894) | | .... | .... | .... | 70 | 10 | 20 | .... | |
| April 30 to May 4 | Surface | .... | 754, 985 | 525 | $\frac{1}{1438}$ (.000695) | 1. 77 | 75 | 10 | 15 | .... | .... | .... | .... | |
| | Bottom | 27 | 377, 170 | 465 | $\frac{1}{811}$ (.001233) | | .... | .... | .... | 70 | 10 | 20 | .... | |
| May 5 to 9 | Surface | .... | 751, 580 | 529 | $\frac{1}{1421}$ (.000704) | 1. 84 | 80 | 10 | 10 | .... | .... | .... | .... | The improved apparatus for obtaining the bottom specimens was used on and after April 30. |
| | Bottom | 21 | 446, 620 | 580 | $\frac{1}{770}$ (.001299) | | .... | .... | .... | 80 | 10 | 10 | .... | |
| May 10 to 14 | Surface | .... | 754, 850 | 510 | $\frac{1}{1480}$ (.000676) | 1. 56 | 80 | 10 | 10 | .... | .... | .... | 3. 23 | Velocity determined May 12. |
| | Bottom | 20 | 729, 390 | 770 | $\frac{1}{947}$ (.001056) | | .... | .... | .... | 80 | 12 | 8 | | |
| May 15 to 19 | Surface | .... | 751, 050 | 530 | $\frac{1}{1417}$ (.000706) | 1. 61 | 70 | 20 | 10 | .... | .... | .... | .... | |
| | Bottom | 19 | 754, 890 | 858 | $\frac{1}{880}$ (.001137) | | .... | .... | .... | 80 | 12 | 8 | .... | |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| May 20 to 24 | Surface | .... | 755, 860 | 752 | $\frac{1}{1005}$ (.000995) | 1.83 | 75 | 10 | 15 | .... | .... | .... | 3.57 | Velocity determined May 22. |
| | Bottom | 16 | 755, 240 | 1, 002 | $\frac{1}{754}$ (.001327) | | .... | .... | .... | 80 | 15 | 5 | | |
| May 25 to 29 | Surface | .... | 763, 550 | 672 | $\frac{1}{1136}$ (.000880) | 1.23 | 70 | 25 | 5 | .... | .... | .... | ........ | |
| | Bottom | 15 | 760, 180 | 820 | $\frac{1}{927}$ (.001079) | | .... | .... | .... | 70 | 20 | 10 | ........ | |
| May 30 to June 3 | Surface | .... | 771, 160 | 658 | $\frac{1}{1172}$ (.000853) | 1.31 | 85 | 10 | 5 | .... | .... | .... | 3.66 | Velocity determined June 3. |
| | Bottom | 16 | 769, 870 | 860 | $\frac{1}{895}$ (.001117) | | .... | .... | .... | 70 | 20 | 10 | | |
| June 4 to 8 | Surface | .... | 739, 700 | 709 | $\frac{1}{1043}$ (.000958) | 1.43 | 80 | 10 | 10 | .... | .... | .... | ........ | |
| | Bottom | 18 | 737, 520 | 1, 008 | $\frac{1}{732}$ (.001367) | | .... | .... | .... | 80 | 15 | 5 | ........ | |
| June 9 to 13 | Surface | .... | 723, 710 | 847 | $\frac{1}{854}$ (.001170) | 1.38 | 80 | 10 | 10 | .... | .... | .... | 3.88 | Velocity determined June 13. |
| | Bottom | 21 | 726, 260 | 1, 175 | $\frac{1}{618}$ (.001618) | | .... | .... | .... | 80 | 10 | 10 | | |
| June 14 to 18 | Surface | .... | 724, 780 | 917 | $\frac{1}{790}$ (.001265) | 1.29 | 90 | 10 | .... | .... | .... | .... | ........ | |
| | Bottom | 20 | 718, 100 | 1, 170 | $\frac{1}{614}$ (.001629) | | .... | .... | .... | 80 | 10 | 10 | ........ | |

4. *Velocity measurement.*—The mean velocity of the river and the amount of the discharge were computed from the mid-depth velocities by the following formulæ, taken from Humphrey and Abbot's Report on the Mississippi River:

$$V_m = V_{\frac{1}{2}D} - \frac{1}{72}(b\,v)^{\frac{1}{2}}$$

$$Q = a\,v = [a'\,V_m]$$

$$b = \frac{1.69}{(D+1.5)^{\frac{1}{2}}}$$

Where

$V_m$ = mean velocity in any vertical plane in feet per second.
$V_{\frac{1}{2}D}$ = mid-depth velocity in any vertical plane in feet per second.
$v$ = mean velocity for the entire cross-section in feet per second.
$D$ = mean depth of the division.
$a$ = area of the entire cross-section in square feet.
$a'$, $a''$, &c. = areas of the divisions.
$Q$ = quantity of water discharged in cubic feet per second.
[ ] = sign of summation.

The following is a table of the results:

| Date. | Stage of water above low-water at Helena. | v = mean velocity of river. | Q = quantity of water discharged in cubic foot per second. |
|---|---|---|---|
| 1879. | | *Feet.* | |
| April 4 | 33. 2 | 4. 2636 | 728, 543 |
| May 12 | 16. 3 | 3. 2297 | 304, 672 |
| May 22 | 14. 4 | 8. 5660 | 281, 601 |
| June 3 | 14. 2 | 3. 6633 | 294, 868 |
| June 13 | 18. 3 | 3. 8822 | 385, 531— |

5. *River slope.*—The following table embodies the results of all observations for river slope:

| Date. | Stage of water above low-water at Helena. | Number of simultaneous readings. | Fall. | | | Remarks. |
|---|---|---|---|---|---|---|
| | | | △ 33—G. 1. Dist. = 1340m. | G. 1.—△ 37 Dist. = 1730m. | △ 33—△ 37 Dist. = 3070m. | |
| 1879. | | | *Feet.* | *Feet.* | *Feet.* | |
| March 31 | 33. 2 | 8 | 0. 209 | 0. 408 | 0. 608 | |
| April 4 | 33. 2 | 8 | .............. | 0. 375 | .............. | |
| May 12 | 16. 3 | 8 | 0. 272 | 0. 725 | 0. 999 | Wind 4 miles per hour up-stream. |
| May 20 | 14. 4 | 9 | 0. 402 | 0. 557 | 0. 959 | Still. |
| May 21 | 14. 4 | 16 | 0. 392 | 0. 671 | 1. 063 | Wind 4 to 6 miles per hour down-stream. |
| May 22 | 14. 4 | 16 | 0. 410 | 0. 553 | 0. 963 | Wind per hour down-stream. |
| May 24 | 14. 1 | 17 | 0. 399 | 0. 556 | 0. 955 | |
| June 3 | 14. 2 | 17 | 0. 368 | 0. 599 | 0. 967 | Wind 4 miles per hour down-stream. |
| June 13 | 18. 3 | 16 | 0. 249 | 0. 478 | 0. 727 | Still. |

6. *Daily gauge-readings.*—The results of the daily gauge-readings are shown by the curve of oscillations on Plate I.

Much of the care and rapidity with which most of the work was done is due to Recorder W. M. Childs.

On June 21 the quarter-boat was towed to Memphis by the steamer Mike Davis, and the party was disbanded on the 23d.

Very respectfully, your obedient servant,

J. B. JOHNSON,
*Assistant Engineer.*

Maj. C. B. COMSTOCK,
*Corps of Engineers.*

## APPENDIX No. 11.

### CHARTS.

### 1.—LIST OF PUBLISHED LAKE-SURVEY CHARTS, JUNE 30, 1879.

| Number. | Name of chart. | Scale. | Year of publication. |
|---|---|---|---|
| 1 | Lake Erie | 1–400, 000 | 1852 |
| 2 | West end Lake Erie | 1–120, 000 | 1852 |
| 3 | Kelley's and Bass Islands, Lake Erie | 1–50, 000 | 1852 |
| 4 | Straits of Mackinac | 1–120, 000 | 1856 |
| 5 | East Neebish Rapids, Saint Mary's River | 1–15, 000 | 1854 |
| 6 | Saginaw River | 1–10, 000 | 1856 |
| 7 | Saint Clair Flats | 1–32, 000 | 1857 |
| 8 | Buffalo Harbor | 1–30, 000 | 1857 |
| 9 | Tawas Harbor Lake Huron | 1–16, 000 | 1857 |
| 10 | Beaver Island Group, Lake Michigan | 1–120, 000 | 1855 |
| 11 | Eagle Harbor, Lake Superior | 1–500, 000 | 1858 |
| 12 | Agate Harbor, Lake Superior | 1–10, 000 | 1858 |
| 13 | River Saint Marie, No. 1 | 1–40, 000 | 1858 |
| 14 | River Saint Marie, No. 2 | 1–40, 000 | 1858 |
| 15 | Maumee Bay, Lake Erie | 1–30, 000 | 1858 |
| 16 | Eagle River, Lake Superior | 1–10, 000 | 1859 |
| 17 | Ontonagon Harbor, Lake Superior | 1–16, 000 | 1859 |
| 18 | Saginaw Bay, Lake Huron | 1–120, 000 | 1860 |
| 19 | Thunder Bay, Lake Huron | 1–40, 000 | 1860 |
| 20 | Marquette Harbor, Lake Superior | 1–50, 000 | 1860 |
| 21 | Presque Isle and Middle Island, Lake Huron | 1–40, 000 | 1860 |
| 22 | Lake Huron | 1–400, 000 | 1860 |
| 23 | South end Lake Huron | 1–120, 000 | 1861 |
| 24 | Grand Island, Lake Superior | 1–25, 000 | 1862 |
| 25 | West end Lake Superior | 1–32, 000 | 1863 |
| 26 | Grand and Little Traverse Bays, Lake Michigan | 1–120, 000 | 1863 |
| 27 | North end Green Bay | 1–120, 000 | 1864 |
| 28 | Copper Harbor, Lake Superior | 1–10, 000 | 1866 |
| 29 | L'Anse and Keweenaw-Bay, Lake Superior | 1–30, 000 | 1866 |
| 30 | Portage Lake and River | 1–30, 000 | 1865 |
| 31 | Lake Superior, No. 1 | 1–400, 000 | 1872 |
| 32 | Lake Superior, No. 2 | 1–400, 000 | 1870 |
| 33 | North end Lake Michigan | 1–400, 000 | 1867 |
| 34 | Huron Island | 1–30, 000 | 1869 |
| 35 | South end Green Bay | 1–120, 000 | 1864 |
| 36 | Lake Superior, No. 3 | 1–400, 000 | 1873 |
| 37 | Saint Clair River | 1–40, 000 | 1872 |
| 38 | Isle Royale, Lake Superior | 1–30, 000 | 1872 |
| 39 | Mouth of Detroit River | 1–20, 000 | 1874 |
| 40 | City of Chicago | 1–20, 000 | 1874 |
| 41 | Lake Saint Clair | 1–50, 000 | 1874 |
| 42 | Saint Lawrence River, No. 1 | 1–30, 000 | 1874 |
| 43 | Sandusky Bay | 1–20, 000 | 1874 |
| 44 | Saint Lawrence River, No. 2 | 1–30, 000 | 1875 |
| 45 | Saint Lawrence River, No. 3 | 1–30, 000 | 1875 |
| 46 | Saint Lawrence River, No. 4 | 1–30, 000 | 1876 |
| 47 | Sand Beach Harbor of Refuge, Lake Huron | 1–8, 000 | 1876 |
| 48 | Niagara Falls | 1–10, 000 | 1876 |
| 49 | Saint Lawrence River, No. 5 | 1–30, 000 | 1876 |
| 50 | South end Lake Michigan | 1–400, 000 | 1876 |
| 51 | Coast-chart No. 5, Lake Michigan | 1–80, 000 | 1876 |
| 52 | Coast-chart No. 3, Lake Michigan | 1–80, 000 | 1876 |
| 53 | Saint Lawrence River, No. 6 | 1–30, 000 | 1876 |
| 54 | Coast-chart No. 2, Lake Michigan | 1–80, 000 | 1877 |
| 55 | Coast-chart No. 1, Lake Michigan | 1–80, 000 | 1877 |
| 56 | Detroit River | 1–40, 000 | 1876 |
| 57 | Coast-chart No. 6, Lake Michigan | 1–80, 000 | 1877 |
| 58 | Coast-chart No. 7, Lake Michigan | 1–80, 000 | 1877 |
| 59 | Coast-chart No. 4, Lake Michigan | 1–80, 000 | 1877 |
| 60 | Coast-chart No. 1, Lake Ontario | 1–80, 000 | 1877 |
| 61 | Lake Ontario | 1–400, 000 | 1877 |
| 62 | Coast-chart No. 9, Lake Michigan | 1–80, 000 | 1878 |
| 63 | Coast-chart No. 8, Lake Michigan | 1–80, 000 | 1878 |
| 64 | Coast-chart No. 2, Lake Ontario | 1–80, 000 | 1878 |
| 65 | Coast-chart No. 3, Lake Ontario | 1–80, 000 | 1878 |
| 66 | Coast-chart No. 4, Lake Ontario | 1–80, 000 | 1878 |
| 67 | Coast-chart No. 5, Lake Ontario | 1–80, 000 | 1878 |
| 68 | Coast-chart No. 2, Lake Erie | 1–80, 000 | 1879 |
| 69 | Coast-chart No. 3, Lake Erie | 1–80, 000 | 1879 |

## 2.—LIST OF PUBLISHED MISSISSIPPI RIVER CHARTS, JUNE 30, 1879.

| Number. | Name of chart. | Scale. | Year of publication. |
|---|---|---|---|
| 1 | Mississippi River, vicinity of Cairo, Ill | 1-10,000 | 1878 |
| 2 | Mississippi River, vicinity of Cairo, Ill | 1-10,000 | 1878 |
| 3 | Mississippi River, vicinity of Cairo, Ill | 1-10,000 | 1878 |
| 4 | Mississippi River, vicinity of Memphis, Tenn | 1-10,000 | 1878 |
| 5 | Mississippi River, vicinity of Memphis, Tenn | 1-10,000 | 1878 |
| 6 | Mississippi River, vicinity of Memphis, Tenn | 1-10,000 | 1878 |
| 7 | Mississippi River, vicinity of Memphis, Tenn | 1-10,000 | 1878 |
| 8 | Mississippi River, vicinity of Memphis, Tenn | 1-10,000 | 1878 |
| 9 | Mississippi River, vicinity of Memphis, Tenn | 1-10,000 | 1878 |

## 3.—TABLE SHOWING THE ANNUAL ISSUE OF CHARTS OF THE NORTHERN AND NORTHWESTERN LAKES.

| | |
|---|---|
| Prior to October 1, 1857 | 2,500 |
| October 1, 1857, to October 1, 1858 | 1,675 |
| October 1, 1858, to October 1, 1859 | 2,600 |
| October 1, 1859, to October 1, 1860 | 4,890 |
| October 1, 1860, to October 1, 1861 | 3,254 |
| October 1, 1861, to October 1, 1862 | 5,245 |
| October 1, 1862, to October 1, 1863 | 4,084 |
| October 1, 1863, to October 1, 1864 | 3,283 |
| October 1, 1864, to October 1, 1865 | 2,589 |
| October 1, 1865, to July 1, 1866 | 2,082 |
| July 1, 1866, to July 1, 1867 | 5,464 |
| July 1, 1867, to July 1, 1868 | 6,354 |
| July 1, 1868, to July 1, 1869 | 5,634 |
| July 1, 1869, to July 1, 1870 | 4,597 |
| July 1, 1870, to July 1, 1871 | 5,328 |
| July 1, 1871, to July 1, 1872 | 3,649 |
| July 1, 1872, to July 1, 1873 | 5,546 |
| July 1, 1873, to July 1, 1874 | 7,701 |
| July 1, 1874, to July 1, 1875 | 5,039 |
| July 1, 1875, to July 1, 1876 | 4,101 |
| July 1, 1876, to July 1, 1877 | 3,156 |
| July 1, 1877, to June 1, 1878 | 6,623 |
| June 1, 1878, to July 1, 1879 | 4,499 |

## 4.—LIST OF TRACINGS FURNISHED TO PARTIES FROM JULY 1, 1878, TO JUNE 30, 1879.

| Name. | Date. | Locality. |
|---|---|---|
| Maj. J. M. Wilson, Corps of Engineers | March 14, 1879 | Erie Harbor, Pa. |
| Maj. D. C. Houston, Corps of Engineers | May 6, 1879 | Vicinity of Waukegan, Ill, |

# APPENDIX N N.

## REPORT OF LIEUTENANT-COLONEL G. K. WARREN, CORPS OF ENGINEERS, ON MAPS OF CAMPAIGNS AND BATTLEFIELDS.

UNITED STATES ENGINEER OFFICE,
*Newport, R. I., September* 29, 1879.

GENERAL: I have the honor to transmit herewith a report on the "maps of campaigns and battlefields."

* * * * * * *

Very respectfully,

G. K. WARREN,
*Lieut. Col. of Engineers, Bvt. Maj. Gen., U. S. A.*

The CHIEF OF ENGINEERS, U. S. A.

---

### REPORT.

At the date of the last annual report the survey of the battlefield of August 28, 29, and 30, 1862, near Groveton and between Bull Run and Broad Run, Virginia, was in progress, and as a means of making it, $1,000 had been allotted.

In order to furnish information for the use of the board of which General Schofield was president, the field-work was suspended as soon as the most important part of the field had been covered, and a map rapidly prepared, which was submitted in evidence before the board at West Point July 8, 1878.

Up to this time but little more than half the money allotted had been expended, and it was my intention to return to the field and extend the work, but the great demand for copies of the map for use on the investigation and the necessity of compiling an additional map from such other maps as were available in order to exhibit the relation of the part surveyed to the outlying country, exhausted all the fund.

An estimate was afterward submitted to make certain additional surveys at an expense of $500, and more extended ones at an expense of $1,500; but it was decided that the purposes of the investigation of the board could be accomplished with the information on hand, and no further surveys were ordered.

I have, however, made every effort to secure additional information in regard to maps previously constructed in this region, and the manner of their construction, by correspondence with such survivors of the war as were engaged in mapping, and have had considerable success.

It must be remembered that the battlefield of August 28, 29, and 30, 1862, laps to the eastward, upon the battlefield of July 21, 1861, and upon that at Bristoe Station in August, 1862, and again in October, 1863. Its interesting campaign features extend up to the defenses of Washington on the north, to the Rappahannock River on the south, and the Shenandoah River on the west, and are intimately connected with the campaigns of Antietam, Chancellorsville, and Gettysburg.

The two great armies crossed and recrossed this ground in the years 1861, 1862, and 1863; the results of which gave to the Union Army a preponderance that ever afterward excluded the other from this field.

It is not yet properly mapped. Each of the campaigns has its records, and its hastily-made maps, which taken together without discrimination produce nothing but confusion, but which are capable of being reduced to harmony, so as to fully illustrate each campaign without confusion, if but a few check surveys can now be run and impossible agreements of data disposed of by an examination on the ground so as to reject the ones found to be erroneous.

I have during the year 1879 obtained some surveys and data not yet used in compilation, and have the prospect of getting some of the original county maps of Virginia by John Wood, from which Hermann Boye made his compilation, which county maps may enable us to decide what "principal streams and roads" shown on the Boye map are represented from actual surveys, and which are not.

I have been, in different official orders, connected with this work since the close of the war in 1865. A letter from the Chief of Engineers dated June 26, 1865, says, "Major G. K. Warren, Corps of Engineers, is assigned to duty * * * to prepare his campaign reports of the operations of the Army corps under his command." Having prepared my data to begin this work, I applied for authority and means to hire a clerk and draughtsman to assist me. On November 4, 1865, I received notice from the Chief of Engineers "that the views of the Secretary of War on the subject of expenditures by this department will not justify your employment of a draughtsman and clerk to enable you to make your report, and that it will be necessary to take so much more time to effect your object as will enable you to prepare your own reports and accompanying papers and maps to illustrate the same."

I then gave my principal attention to arranging my papers and replying to a large correspondence with our disbanded Army, in doing which I had no assistant, and completed a report of operations at Five Forks and the three preceding days, by March, 1866. I was then assigned to duty as junior member of an engineer board without a clerk, which occupied me till the end of May. On the last of July I was assigned to a field of new duty on the Upper Mississippi, succeeded by many other engineering duties, without neglecting which I could scarce give a thought to military reports and maps, until the Mississippi River bridge report was completed in the early part of 1878.

However, in October, 1868, I was assigned by the Chief of Engineers to the duty of making a survey and map of the battlefield of Gettysburg, at which battle I was chief engineer of the Army of the Potomac. This map was reported in the last annual report, as published and distributed. This map of the battlefield of Gettysburg should be accompanied by a map showing the routes marched over in that campaign, for which map I had many notes taken at the time, but which my advancement after the battle to the command of an army corps gave me no chance to prepare. To harmonize these notes with others will require comparisons on the ground and additional surveys.

The difficulties in using the data in a compilation arises from the fact that much of the reconnaissances were made on horseback with estimated distances; that the odometer surveys are discrepant, owing probably to the roads being too rough for such an instrument; that proper connections were not made between important lines or points; and that the attention of those reconnoitering was given rather to the country in advance, where the enemy was liable to interfere, than to the secure regions behind our lines.

Were the only object now to secure a good map of the country as it now is, entirely new surveys might be best; but to have maps to illustrate the campaigns in the war, it will be necessary to use the material then collected, and only such new surveys need be made as will properly unite the data of the war maps. Not a little importance to understanding war operations in certain places and times depends upon a proper showing of the errors of these war maps.

I have also endeavored, and am continuing the effort, to obtain data for a history of the topographical engineering work of the two Corps of Engineers within the field of operations north of the Rappahannock and Rapid Ann rivers from the beginning of the war to the time of the close of the Gettysburg campaign, all of which contributed to the information upon which that campaign was conducted.

In presenting the map of my surveys before the investigating board at West Point, in July, 1878, I stated that it was my intention to accompany it by a topographical memoir. This I had prepared as nearly complete as I then could, but it was my intention to revisit the ground as soon as I could before concluding it. There were certain discrepancies in surveys of regions contiguous to my survey which it was important to clear up on the ground—things more easily corrected than described for others to do. I have been unable to revisit the field, and still withhold the memoir.

I desire that existing orders in regard to these surveys as heretofore intrusted to me may be allowed to remain in force so as to retain my official relation to the subject, and thus entitle me to that consideration from others which is due to public work.

The best compiled map I could make with the data then on hand was sent to the Engineer headquarters on January 31, 1879.

Respectfully submitted.

G. K. WARREN,
*Lieutenant-Colonel of Engineers, Bvt. Major-General, U. S. A.*

# APPENDIX O O.

# ANNUAL REPORT OF CAPTAIN GEORGE M. WHEELER, CORPS OF ENGINEERS, U. S. A., FOR THE FISCAL YEAR ENDING JUNE 30, 1879.

## GEOGRAPHICAL SURVEYS OF THE TERRITORY OF THE UNITED STATES WEST OF THE ONE HUNDREDTH MERIDIAN, IN THE STATES AND TERRITORIES OF CALIFORNIA, COLORADO, KANSAS, NEBRASKA, NEVADA, OREGON, TEXAS, ARIZONA, IDAHO, MONTANA, NEW MEXICO, UTAH, WASHINGTON, AND WYOMING.

## CONTENTS.

### REPORT.

Page.

Summary of field and office operations .......... 1979

Astronomical .......... 1982

Geodetic and topographical (including topographic and hydrographic) survey of portions of Great Salt Lake Basin .......... 2096

Barometric hypsometry, with tables of altitudes of initial reference and other stations .......... 2105

Topographical maps and progress sheet .......... 2117

Land classification areas and maps .......... 2118

Routes of communication .......... 2122

Mining notes .......... 2165

Natural history investigations and collections (including geology, zoology, &c.) 2176

Publications made and in progress .......... 2177

Conclusion and estimates .......... 2184

### APPENDIXES.

A.—Executive and descriptive report of First Lieut. Samuel E. Tillman, Corps of Engineers, chief of party, sextant and triangulation observer .......... 2187

B.—Executive and descriptive report of First Lieut. Thomas W. Symons, Corps of Engineers, chief of party, sextant and triangulation observer .......... 2192

C.—Executive and descriptive report of Second Lieut. Eugene Griffin, Corps of Engineers, chief of party, sextant and triangulation observer .......... 2201

D.—Executive and descriptive report of Second Lieut. Willard Young, Corps of Engineers, chief of party, sextant and triangulation observer .......... 2206

D (sub).—Descriptive report, by Lieutenant Young, of the operations of a special party engaged in survey of Great Salt Lake, season of 1879 .......... 2213

E.—Executive and descriptive report of First Lieut. Rogers Birnie, jr., Ordnance Department, chief of party, sextant and triangulation observer .... 2215

F.—Executive and descriptive report of First Lieut. M. M. Macomb, Fourth Artillery, chief of party, sextant and triangulation observer .......... 2231

G.—Executive report of Second Lieut. H. H. Ludlow, Third Artillery, chief of party and triangulation observer .......... 2239

H.—Executive report of a special astronomical party stationed at Ogden, Utah, by Prof. T. H. Safford, Ph. D., assistant .......... 2242

I.—Executive report of a special astronomical party operating in California, Oregon, and Washington Territory, by J. H. Clark, assistant .......... 2243

J.—Executive report of a special astronomical party operating in New Mexico and Texas, by Miles Rock, assistant .......... 2246

Page.
K.—Report of a special geological party operating in Colorado and New Mexico from Spanish Peaks to the south, field season of 1878, by Prof. John J. Stevenson, Assistant .......... 2249
K (sub).—Preliminary report of a special geological party operating in Colorado and New Mexico, field season of 1879, by Prof. John J. Stevenson .......... 2259
L.—Ornithological report upon observations and collections made in portions of California, Nevada, and Oregon, by Assistant H. W. Henshaw .......... 2260

ILLUSTRATIONS.

1. Sketch of astronomical station of 1878, near Fort Bliss, Texas .......... 2059
2. Progress map .......... 2117
3. Outline map of the Comstock Lode, Nevada, and vicinity .......... 2166
4. Itinerary of routes followed and main points occupied by a field party of 1878 in Northern California .......... 2189
5. Crater view, Northern California .......... 2190
6. Line and profile sketch from near Fest's Ferry, Rio Grande, N. M., to Saint Johns and vicinity, Little Colorado, Arizona .......... 2218

# REPORT.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
*Washington, D. C., June* 30, 1879.

GENERAL: I have the honor to submit the usual report for the fiscal year ending June 30, 1879.

Appropriations for office work alone having been granted at the past session of Congress, all parties were withdrawn and field work suspended at the close of the fiscal year.

## SUMMARY OF FIELD AND OFFICE OPERATIONS.

Early in July, 1878, nine parties, two operating in double lines, of the expedition of that year took the field as follows: One at Fort Stanton, N. Mex.; two at Fort Garland, Colo.; three at Ogden, Utah; two at Carson, Nev., and Fort Bidwell, Cal.

The separately organized astronomical parties commenced their labors, one at the observatory of the survey at Ogden, Utah, a second at Fort Bliss, Tex., and a third at The Dalles, Oreg.

The political divisions entered by the above parties, connecting areas with those occupied heretofore, were California, New Mexico, Texas, Arizona, Utah, Nevada, Colorado, Oregon, Washington Territory, and in portions embraced by atlas sheets 20 A, 20 C, 29 A, 29 C, 38 B, 56 B, 56 D, 61 D, 70 A, 70 C, 73, 76, 77 D, 78 A, 83, 84, 90 A, and 90 B. (See progress map herewith.)

The disbandment of the expedition was successfully accomplished at Sacramento, Cal.; Fort Bidwell, Cal.; Ogden, Utah; Fort Garland, Colo.; Fort Stanton, and Fort Bayard, N. Mex.

The parties were in the field for a period exceeding five months without casualties, and the accumulation of data by the observers, 46 in number, exceeded that of any former year. Valuable observations, other than those required for the resulting topographical map, were gathered by specialists in geology, zoology, upon mining at the Comstock Lode, Nevada, and elsewhere.

During April, 1879, a special party of the Utah section was engaged in the topographic and hydrographic survey of the Great Salt Lake and vicinity, while two parties of the Colorado section at Fort Garland, Colo., and one, working in two divisions, of the California section at Sacramento, Cal., were organized early in May to prosecute their labors in parts of the political divisions of Colorado, New Mexico, Utah, and California, embraced by atlas sheets 41 A, 41 C, 41 D, 52 D, 56 D, 69 D, 70 A, 70 C, 77 B, 78 A. (See progress map herewith.) The parties were withdrawn from the field to resume office labors June 30, 1879.

Among these parties, and from the chief of which no special report was received, was one engaged in triangulation observations in Central Colorado, under Louis Nell, assistant. This party was successful in its operations, locating along its route a number of new mining camps, as

Silver Cliff, Leadville, Ten Mile, Carbonate, Frying Pan Gulch, Monarch, and the new discoveries in the basin of the Gunnison.

The group of mines with Leadville as a center was found to be of undoubted present richness and of great future promise.

Astronomical stations for telegraphic longitudes and zenith telescope latitudes were occupied: 1. Ogden, Utah (connecting station); 2. Walla Walla, Wash.; 3. Dalles, Oreg.; 4. Fresno, Cal.; 5. Fort Bliss, Tex.; 6. Fort Bayard, N. Mex.

As usual, at the Washington office a number of draughtsmen and computers were steadily employed in reducing observations, plotting results, and in the delineation of the final atlas sheets. The field reducing office at Ogden was discontinued during the season, to be resumed at its close and continued throughout the year.

The following changes have occurred with regard to the detail of officers serving upon the work:

Lieut. Charles C. Morrison, then Sixth United States Cavalry, repaired to West Point to report to the Superintendent of the Military Academy, August 28, 1878, pursuant to paragraph 2, Special Orders No. 79, Headquarter's of the Army, Adjutant-General's Office, April 13, 1878.

First Lieut. Rogers Birnie, jr., Ordnance Department, was relieved from duty March 12, 1879, by virtue of paragraph 2 of Special Orders No. 59, Headquarters of the Army, Adjutant-General Office, 1879, and to report in person to the Chief of Ordnance.

First Lieut. Thomas W. Symons, Corps of Engineers, was relieved from duty by paragraph 5 of Special Orders No. 58, Headquarters of the Army, Adjutant-General's Office, March 11, 1879, and ordered to report to the commanding general Department of Columbia for duty, and was relieved from the survey June 1, 1879.

Second Lieut. H. H. Ludlow, Third Artillery, was relieved by paragraph 7, Special Orders No. 122, Headquarters of the Army, Adjutant-General's Office, May 23, 1879, from duty, and ordered to join his battery, which took effect June 1, 1879.

Dr. J. T. Rothrock, University of Pennsylvania, completed the proof-reading of his report and those of the several other botanical authors contributing to Vol. VI, that has now been issued from the Government Printing Office.

Prof. F. W. Putnam, curator of the Peabody Museum, Cambridge, Mass., assisted by Dr. C. C. Abbott and Lucien Carr; completed his portions of the manuscript of Vol. VII, which is now passing the different stages of proof at the Government Printing Office.

Sergt. Thomas Knight, Company F; Corpl. Joseph T. Hill, Company I; Artificer Joseph Messer, Company E, and Private Brenholz, Company D, all of the Fourteenth Infantry, were detailed, by selection, pursuant to paragraph 1, Special Order No. 29, Headquarters of the Army, Adjutant-General's Office, February 8, 1878, and have performed excellent service.

To the officers and other assistants engaged in prosecuting the arduous labors of the survey for another field-season, being that of the ninth regular expedition under my command, independent of the winter campaign of 1875–'76 and the season of 1879, just closed, I desire to extend my recognition of the unflagging energy and willingness shown and steady improvement in and rapidity of execution of the several parts of the work.

As usual the supply branches of the War Department have aided, thereby admitting of the retention of a larger number of professional assistants than could have been secured by means of the direct appropriation alone.

Prominent features from the results of observations in the field and reductions in the office are herewith.

### FIELD SEASON OF 1878.

| | | |
|---|---|---|
| Number of main stations occupied for astronomical observations | | 5 |
| Sextant latitude stations | | 90 |
| Bases measured | | 5 |
| Triangles about bases measured | | 64 |
| Main trangulation stations occupied | | 79 |
| Secondary triangulation stations occupied | | 87 |
| Three-point stations occupied | | 763 |
| Stations on meander | | 15,936 |
| Miles measured | | 10,299 |
| Cistern-barometer stations occupied | | 1,041 |
| Aneroid stations occupied | | 7,057 |
| Magnetic variations observed | | 197 |
| Monuments built | | 156 |
| Mining camps visited | | 15 |
| Mineral and thermal springs noted | | 23 |
| Minerals, fossils, and ores; specimens collected, approximately | | 1,467 |
| Mammals, specimens collected | | 11 |
| Birds, specimens collected | | 243 |
| Birds' eggs collected | | 12 |
| Mammals (alcoholic) collected | | 3 |
| Mammal crania collected | | 1 |
| Bird crania collected | | 7 |
| Fishes | specimens | 200 |
| | lots | 12 |
| Snakes | specimens | 25 |
| | lots | 16 |
| Lizards | specimens | 25 |
| | lots | 7 |
| Batrachians | specimens | 50 |
| | lots | 11 |
| Hemiptera collected | | 1 |
| Orthoptera | specimens | 200 |
| | lots | 6 |
| Shells | specimens | 25 |
| | lots | 3 |
| Crustaceans | specimens | 12 |
| | lots | 1 |
| Fossil leaves specimens | | 72 |

### OFFICE—WINTER 1878-'79.

| | |
|---|---|
| Astronomical positions computed | 43 |
| Triangulation stations computed | 90 |
| Geodetic figures computed | 76 |
| Distances computed | 1,808 |
| Azimuths computed | 255 |
| Longitudes and latitudes computed | 292 |
| Cistern-barometer altitudes computed | 1,041 |
| Aneroid-barometer altitudes computed | 6,983 |
| Sheets and parts of sheets plotted (1 inch to 2 miles) | 14 |
| Special sheets drawn (various scales) | 8 |
| Atlas maps (1 inch to 4 miles) published | 6 |
| Atlas maps (1 inch to 4 miles) approaching completion for publication | 4 |
| Reports distributed | 2,633 |
| Maps distributed | 14,906 |
| Sextant latitude stations computed | 60 |
| Mumber of main triangulation stations computed | 59 |
| Number of triangles computed | 904 |
| Number of secondary triangulation stations computed | 37 |
| Number of points fixed by cross-sights computed | 64 |
| Number of three-point stations computed | 132 |

Reports in course of publication: Volumes I, VII, and tables of geographical positions, altitudes, distances, &c.

Maps in course of preparation for publication:

| | |
|---|---|
| Topographical atlas sheets | 23 |
| Land-classification atlas sheets | 12 |
| Geological atlas sheets | 4 |
| Total | 39 |

Certain of the above sheets must await publication until additional triangulation and topographical observations are made; that could, however, be accomplished in one season by a number of small parties, specially equipped for this class of work, and for which funds equal in amount to the present office estimate ($30,000) could be most advantageously expended.

Lieutenant Tillman, chief of party 1, Utah section, also sextant and triangulation observer, was during the winter in charge of the geodetic and barometric reductions, and in preparation of his report, that is submitted herewith as Appendix A.

Lieutenant Symons, as chief of party 1, was engaged in the field as sextant and triangulation observer. He was assigned to the charge of the Ogden office, that had been organized by Lieutenant Tillman at the close of the field season. He was thence ordered to Washington, where, completing his sextant reductions, and while supervising the final plotting of several triangulation sheets, he was relieved June 1. His executive report appears herewith as Appendix B.

The report of Lieutenant Griffin, chief of party 2, Colorado section, appears as Appendix C. This officer made both sextant and triangulation observations in the field, and, during the office period was in charge of the topographical room, and engaged also in computations and in preparation of report.

Lieutenant Young succeeded Lieutenant Symons in charge of the Ogden office. As chief of party 2, Utah section, he was engaged in sextant work in the field and in computations in the office. His report appears as Appendix D. While chief of party on Salt Lake survey, his other duties were that of triangulation observer.

The office duties of Lieutenant Birnie, until date of being relieved, March 1, were in supervision of reductions of work of his parties, both for 1877 and 1878, in preparation of his report (see Appendix E), and incidentally in computations.

Lieutenant Macomb carried on sextant and triangulation observations in the field. His office duties consisted in supervising final map drawings, in preparation of report (see Appendix F), and in topographical reductions.

Party 2, Utah section, with Lieutenant Ludlow as chief, assisted by Francis Klett, was engaged in special base measuring and triangulation observations near Austin, Nev., and at and eastward from Fresno, Cal.

I desire to state the high appreciation in which the services of Messrs. Nell, Thompson, Maxson, Spiller, Carpenter, Karl, and Polhemus, field topographical assistants, are held.

### ASTRONOMICAL.

Five main astronomical stations were occupied during the 1878 season, at or near the following localities: 1. Fort Bliss, Tex.; 2. Fort Bayard, N. Mex. (Miles Rock, observer); 3. Dalles, Oreg.; 4. Walla Walla, Wash.; 5. Fresno, Cal. (John H. Clark, observer).

The plan and methods of observations and subsequent computation are the same as have been in use upon the survey almost continuously since its commencement, and are shown in Vol. II. Observations for personal error were made by the automatic personal equation apparatus devised by Dr. F. Kampf, late assistant of the survey, and perfected at this office.

One of the peculiarities of this astronomical campaign consisted in the opportunity which was afforded of sending signals from Fort Bayard, N. Mex., to Ogden, Utah, via Santa Fé, N. Mex., Denver, Colo., and Cheyenne, Wyo., also via Tucson, Ariz., Fort Yuma, and Sacramento, Cal., thus using two extended circuits, that together make up the sides of a large quadrilateral. Thanks are due to Norvin Green, president Western Union Telegraph Company, and General A. J. Myer, Chief Signal Officer, U. S. A., the former for the free use of the wires of his company, and the latter for his courtesy in extending, while the party was in the field, the immediate use of the government line from Santa Fé southward. The report in the required usual form of the results of the computations by Professor Safford follows herewith.

### REPORT OF PROF. T. H. SAFFORD. COMPUTATIONS OF THE LATITUDE AND LONGITUDE OF FIVE ASTRONOMICAL STATIONS.

SIR: I have the honor to present my report on the computations of the latitudes and longitudes of five stations, namely:

1. Walla Walla, Wash.
2. The Dalles, Oreg.
3. Fresno, Cal.
4. Fort Bliss, Tex.
5. Fort Bayard, N. Mex.

The observations at stations 1, 2, 3 were made by Assistant John H. Clark; those at stations 4, 5 by Assistant Miles Rock; the corresponding time observations at Ogden, Utah, by myself.

The observations made at Ogden include transits taken on every available night during the season, in order to make sure of the rate and error of my chronometers. Nine nights only were so cloudy that no observations were taken, between the dates July 27 and October 10.

These observations were all so far reduced as to give approximate clock and instrumental corrections; and in addition the following right ascensions for 1878.0 of stars not otherwise well determined:

| Star's name. | A. R. 1878.0. | No. of obs. | Declination 1878.0. |
|---|---|---|---|
| | h. m. s. | | ° ′ |
| 166 Heis Herculis | 17 45 39.105 | 12 | + 29 21.4 |
| 204 Heis Herculis | 18 12 46.084 | 11 | 18 5.1 |
| 8 Heis Lyræ | 18 21 16.398 | 6 | 29 45.6 |
| 11 Heis Lyræ | 18 32 8.760 | 8 | 33 22. |
| 28 Heis Cygni | 18 38 2.868 | 9 | 32 8.5 |
| Piazzi XX, 358 | 20 46 17.473 | 6 | 27 47.6 |
| Piazzi XXII, 158 | 22 29 56.660 | 4 | + 19 38.8 |

In a few cases these right ascensions were not used in the reductions, which were completed before they were obtained.

The following is the table of approximate chronometer-corrections, together with the final corrections obtained by the method of least squares for the nights upon which signals were exchanged.

**All the observations of this campaign were by the eye and ear method.**

| Date. | Hour. | Preliminary corrections. | Hour. | Final corrections.* | Hourly rate. |
|---|---|---|---|---|---|
| | h. m. | m. s. | h. | m. s. | s. |
| July 25 | 17 45 | — 0 3.16 | | | |
| 26 | 18 30 | 8.04 | | | |
| 27 | 15 52 | 12.05 | | | |
| | 18 25 | 12.59 | | | |
| 28 | 16 10 | 16.81 | | | |
| | 17 50 | 17.11 | | | |
| 29 | 15 50 | 20.87 | | | |
| | 17 50 | 21.38 | | | |
| 30 | 16 25 | 25.09 | | | |
| 31 | 16 15 | 29.46 | | | |
| Aug. 1 | 16 20 | 33.58 | | | |
| 2 | 16 10 | 37.42 | | | |
| 3 | 18 15 | 41.68 | | | |
| 4 | 16 40 | 45.49 | | | |
| 5 | 16 30 | 49.27 | | | |
| | 18 50 | 49.72 | | | |
| 6 | 17 10 | 53.83 | | | |
| 7 | 18 0 | — 0 56.92 | | | |
| 8 | 18 0 | — 1 0.90 | | | |
| 9 | 17 0 | 4.61 | | | |
| 10 | 17 30 | 8.26 | | | |
| 11 | 17 30 | 11.94 | | | |
| 12 | 17 30 | 15.75 | 18.3 | — 1 15.818 | — 0.152 |
| | 19 10 | 15.87 | | | |
| 13 | 17 30 | 19.14 | | | |
| 14 | 17 30 | 22.86 | | | |
| 17 | 17 30 | 34.70 | | | |
| 18 | 18 30 | 39.19 | | | |
| 19 | 17 30 | 42.77 | 19.25 | — 1 43.126 | — 0.171 |
| | 21 0 | 43.44 | | | |
| 20 | 18 0 | 47.34 | | | |
| 21 | 18 30 | 51.04 | 19.25 | — 1 51.106 | — 0.162 |
| | 20 0 | 51.16 | | | |
| 23 | 18 0 | — 1 59.14 | | | |
| 24 | 18 0 | — 2 3.02 | | | |
| 25 | 18 0 | 7.27 | | | |
| 26 | 18 0 | 11.60 | 19.5 | — 2 11.905 | — 0.175 |
| | 21 0 | 12.19 | | | |
| 27 | 18 0 | 15.75 | | | |
| 28 | 18 0 | 19.80 | 19.5 | — 2 20.041 | — 0.166 |
| | 21 0 | 20.27 | | | |
| 29 | 17 30 | 23.63 | | | |
| 30 | 18 30 | 27.49 | | | |
| | 20 0 | 27.57 | | | |
| 31 | 18 30 | 31.58 | | | |
| Sept. 1 | 19 0 | 35.87 | | | |
| 5 | 19 0 | 50.83 | 20.0 | — 2 51.014 | — 0.153 |
| | 21 0 | 51.23 | | | |
| 6 | 19 0 | 54.42 | | | |
| 7 | 19 0 | 58.18 | 21.0 | — 2 58.570 | — 0.152 |
| | 23 0 | — 2 58.98 | | | |
| 8 | 19 0 | — 3 1.90 | 20.75 | — 3 2.165 | — 0.124 |
| | 22 30 | 2.43 | | | |
| 9 | 18 48 | 4.87 | | | |
| 10 | 19 0 | 2.28 | 20.75 | — 3 2.270 | †+ 0.007 |
| | 22 30 | — 3 2.24 | | | |
| 11 | 19 0 | — 2 59.80 | 20.75 | — 2 59.658 | + 0.168 |
| | 22 30 | 59.55 | | | |
| 12 | 19 0 | 57.58 | 20.75 | — 2 57.446 | + 0.061 |
| | 22 30 | 57.33 | | | |
| 13 | 19 0 | 56.01 | 20.5 | — 2 55.990 | + 0.067 |
| | 22 0 | 55.99 | | | |
| 14 | 19 0 | 54.55 | | | |
| 15 | 19 0 | 53.28 | | | |
| 16 | 19 0 | 51.73 | | | |
| 17 | 21 0 | 50.56 | 21.0 | — 2 50.591 | + 0.048 |
| 19 | 19 0 | 48.02 | | | |
| 20 | 19 0 | 46.07 | 20.5 | — 2 45.984 | + 0.082 |
| | 22 0 | 45.90 | | | |
| 21 | 19 0 | 44.16 | 20.5 | — 2 44.100 | + 0.077 |
| | 22 0 | — 2 44.04 | | | |

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*In this, the least square reduction, the formula for weight used was $w = \frac{1.3}{1 + 0.3, \sec.^2 \delta}$ See vol. II, pp. 343 to 347 of the quarto reports of this survey.

† Mr. Wallace dropped the chronometer, hence this change of rate.

| Date. | Hour. | | Preliminary corrections. | Hour. | Final corrections. | Hourly rate. |
|---|---|---|---|---|---|---|
| | *h.* | *m.* | *m. s.* | *h.* | *m. s.* | *s.* |
| Sept. 22 | 19 | 0 | — 2 42.54 | 20.7 | — 2 42.424 | + 0.076 |
| | 22 | 24 | 42.31 | ........ | ........ | ........ |
| 23 | 22 | 0 | 40.37 | ........ | ........ | ........ |
| 24 | 20 | 0 | 38.79 | ........ | ........ | ........ |
| 25 | 19 | 0 | 36.78 | ........ | ........ | ........ |
| 26 | 19 | 30 | 34.98 | 21.15 | — 2 34.814 | + 0.060 |
| | 22 | 48 | 34.65 | ........ | ........ | ........ |
| 27 | 20 | 0 | 33.65 | 21.5 | — 2 33.603 | + 0.062 |
| | 23 | 0 | 33.54 | ........ | ........ | ........ |
| 28 | 19 | 30 | 31.99 | ........ | ........ | ........ |
| 30 | 20 | 0 | 28.42 | 22.0 | — 2 28.249 | + 0.071 |
| | 0 | 0 | 28.00 | ........ | ........ | ........ |
| Oct. 1 | 20 | 0 | 26.65 | 21.85 | — 2 26.502 | + 0.072 |
| | 23 | 12 | 26.35 | ........ | ........ | ........ |
| 2 | 20 | 30 | 24.74 | ........ | ........ | ........ |
| 3 | 20 | 0 | 22.46 | 21.75 | — 2 22.374 | + 0.092 |
| | 23 | 30 | 22.27 | ........ | ........ | ........ |
| 4 | 19 | 30 | 20.52 | ........ | ........ | ........ |
| 5 | 20 | 0 | 18.56 | 21.50 | — 2 18.440 | + 0.076 |
| | 23 | 0 | 18.31 | ........ | ........ | ........ |
| 6 | 20 | 30 | 16.77 | 21.75 | — 2 16.720 | + 0.066 |
| | 23 | 0 | 16.66 | ........ | ........ | ........ |
| 7 | 20 | 30 | 15.32 | 21.75 | — 2 15.278 | + 0.062 |
| | 23 | 0 | 15.23 | ........ | ........ | ........ |
| 8 | 20 | 48 | 13.84 | 22.0 | — 2 13.763 | + 0.063 |
| | 23 | 12 | 13.66 | ........ | ........ | ........ |
| 10 | 20 | 36 | 10.84 | 21.9 | — 2 10.762 | + 0.063 |
| | 23 | 12 | — 2 10 67 | ........ | ........ | ........ |

In the calculation of these chronometer corrections, the star-catalogues used were the German ephemerides of 539 stars, the American Ephemeris, and the Survey Catalogue of 2,018 stars. The chronometer corrections need to be increased by about $0^s.01$ to correspond to the revised German ephemerides, published in 1878 or 1879, after my return from the field; this revision was employed in the reduction of Mr. Clark's and Mr. Rock's observations.

Observations for personal equations with Mr. Clark were made at Ogden, which here follow; the bracketed chronometer corrections ($dt+m$) are those given by the polar stars. The difference is almost exactly zero, and has been neglected, as Mr. Clark observed with a different instrument from his own.

*Observations for personal equation.—J. H. Clark and T. H. Safford.*

**October 19, 1878. First group. Clamp East.**

| Star's name. | T. | | | $n$ tan $\delta$. | $c$ sec $\delta$. | T′. | A. R. | $dt+m+2^m$. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | C. | S. |
| | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *s.* | *s.* | *s.* |
| γ Cygni | 20 | 19 | 42.83 | —0.28 | +0.26 | 42.81 | 53.21 | +10.40 | |
| 41 Cygni | | 26 | 16.79 | —0.21 | +0.24 | 16.82 | 27.28 | | +10.46 |
| ε Delphini | | 29 | 15.78 | —0.07 | +0.20 | 15.91 | 26.18 | 10.27 | |
| β Delphini | | 33 | 42.20 | —0.09 | +0.21 | 42.32 | 52.75 | | 10.43 |
| δ Delphini | | 39 | 38.48 | —0.09 | +0.21 | 38.60 | 48.89 | 10.29 | |
| ε Cygni | | 43 | 8.66 | —0.23 | +0.24 | 8.67 | 19.17 | | 10.50 |
| Piazzi XX 358 | | 48 | 9.98 | —0.18 | +0.23 | 10.03 | 30.32 | 10.29 | |
| 32 Vulpeculae | | 51 | 14.20 | —0.18 | +0.23 | 14.25 | 24.52 | | 10.27 |
| Br. 2749 | 20 | 54 | 52.18 | —1.95 | +1.16 | 51.39 | 1.78 | [10.39] | |
| 61 Cygni | 21 | 3 | 18.24 | —0.27 | +0.25 | 18.22 | 28.65 | | 10.48 |
| ζ Cygni | 21 | 9 | 37.10 | —0.19 | +0.23 | 37.14 | 47.59 | 10.45 | |

*Observations for personal equations.—J. H. Clark and T. H. Safford.*

October 19, 1878. Second group. Clamp east.

| Star's name. | T. | | | n tan δ. | c sec δ. | T′. | A. R. | dt + m + 2m. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | C. | S. |
| | h. | m. | s. | s. | s. | s. | s. | s. | s. |
| 20 Cephei | 22 | 3 | 10.51 | −0.36 | +0.43 | 10.58 | 20.68 | | 10.10 |
| π² Pegasi | | 6 | 27.06 | −0.12 | +0.24 | 27.18 | 37.57 | 10.39 | |
| Piazzi XXII. 32 | | 9 | 56.29 | −0.10 | +0.23 | 56.42 | 6.76 | | 10.34 |
| 1 Lacertæ | | 12 | 31.86 | −0.14 | +0.25 | 31.97 | 42.43 | 10.46 | |
| 31 Pegasi | | 17 | 24.06 | −0.04 | +0.20 | 24.22 | 34.53 | | 10.31 |
| Piazzi XXII. 113 | | 24 | 4.10 | −0.12 | +0.23 | 4.21 | 14.48 | 10.27 | |
| 39 Pegasi | | 28 | 35.01 | −0.07 | +0.21 | 35.15 | 45.50 | | 10.35 |
| Piazzi XXII. 158 | | 31 | 49.30 | −0.07 | +0.21 | 49.44 | 0.40 | 10.96 | |
| 10 Lacertæ | | 35 | 40.19 | −0.15 | +0.26 | 40.30 | 50.84 | | 10.54 |
| η Pegasi | | 39 | 10.16 | −0.11 | +0.23 | 0.28 | 20.74 | 10.46 | |
| λ Pegasi | | 42 | 32.61 | −0.08 | +0.22 | 32.75 | 43.05 | | 10.30 |
| π Cephei | 23 | 5 | 54.62 | −0.70 | +0.76 | 54.68 | 5.34 | [10.66] | |
| 130 Heis Pegasi | | 11 | 50.53 | −0.09 | +0.22 | 50.66 | 1.05 | | 10.39 |
| τ Pegasi | | 16 | 29.27 | −0.08 | +0.22 | 29.41 | 39.96 | 10.55 | |
| υ Pegasi | | 21 | 10.86 | −0.08 | +0.22 | 11.00 | 21.49 | | 10.49 |
| 70 Pegasi | | 24 | 52.56 | −0.04 | +0.20 | 52.72 | 3.21 | 10.49 | |
| 72 Pegasi | | 29 | 47.46 | −0.11 | +0.23 | 47.58 | 58.18 | | 10.60 |
| 153 Heis Pegasi | | 32 | 21.00 | −0.12 | +0.24 | 21.12 | 31.63 | 10.51 | |
| γ Cephei | | 36 | 15.68 | −0.82 | +0.89 | 15.75 | 26.58 | | [10.83] |

October 20, 1878. First group. Clamp west.

| Star's name. | T. | | | n tan δ. | c sec δ. | T′. | A. R. | dt + m + 2m. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | S. | C. |
| | h. | m. | s. | s. | s. | s. | s. | s. | s. |
| λ Cephei | 20 | 14 | 44.16 | −1.07 | −0.91 | 42.18 | 55.33 | [13.15] | |
| 39 Cygni | | 20 | 49.38 | −0.15 | −0.24 | 48.99 | 1.85 | | 12.86 |
| 41 Cygni | | 26 | 14.83 | −0.14 | −0.23 | 14.46 | 27.30 | 12.84 | |
| ε Delphini | | 29 | 13.92 | −0.05 | −0.20 | 13.67 | 26.17 | | 12.50 |
| β Delphini | | 33 | 40.51 | −0.06 | −0.21 | 40.24 | 52.74 | 12.50 | |
| δ Delphini | | 39 | 36.56 | −0.06 | −0.21 | 36.29 | 48.88 | | 12.59 |
| ε Cygni | | 43 | 6.93 | −0.16 | −0.24 | 6.53 | 19.15 | 12.62 | |
| Piazzi XX. 358 | | 48 | 7.95 | −0.11 | −0.22 | 7.62 | 20.84 | | 12.72 |
| 32 Vulpeculæ | | 51 | 12.26 | −0.11 | −0.22 | 11.93 | 24.51 | 12.58 | |
| 61 Cygni pr | 21 | 3 | 16.35 | −0.19 | −0.25 | 15.91 | 28.63 | | 12.72 |
| ζ Cygni | | 9 | 35.11 | −0.14 | −0.23 | 34.74 | 47.58 | 12.84 | |
| ν Cygni | | 14 | 44.62 | −0.16 | −0.24 | 44.22 | 57.05 | | 12.88 |
| 1 Pegasi | | 18 | 17.47 | −0.08 | −0.21 | 17.18 | 29.88 | 12.70 | |
| 7444 | | 20 | 59.82 | −0.12 | −0.22 | 59.48 | 12.09 | | 12.61 |
| 70 Cygni | | 24 | 13.41 | −0.18 | −0.25 | 12.98 | 25.88 | 12.90 | |
| Gr. 3511 | | 30 | 11.09 | −1.36 | −1.15 | 8.58 | 21.08 | | [12.50] |

October 20, 1878. Second group. Clamp west.

| Star's name. | T. | | | n tan δ. | c sec δ. | T′. | A. R. | dt + m + 2m. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | S. | C. |
| | h. | m. | s. | s. | s. | s. | s. | s. | s. |
| π² Pegasi | 22 | 6 | 24.92 | −0.15 | −0.24 | 24.53 | 37.56 | 13.03 | |
| Piazzi XXII. 32 | | 9 | 54.14 | −0.13 | −0.23 | 53.78 | 6.77 | | 12.99 |
| 1 Lacertæ | | 12 | 30.03 | −0.18 | −0.25 | 29.60 | 42.45 | 12.85 | |
| 31 Pegasi | | 17 | 21.98 | −0.05 | −0.20 | 21.73 | 34.52 | | 12.70 |
| 39 Pegasi | | 28 | 32.86 | −0.09 | −0.21 | 32.56 | 45.51 | 12.95 | |
| Piazzi XXII. 158 | | 31 | 47.68 | −0.09 | −0.21 | 47.38 | 0.41 | 13.03 | |
| 10 Lacertæ | | 35 | 37.98 | −0.19 | −0.26 | 37.53 | 50.83 | | 13.30 |
| η Pegasi | | 39 | 7.99 | −0.14 | −0.23 | 7.62 | 20.73 | 13.11 | |
| λ Pegasi | | 42 | 30.38 | −0.10 | −0.22 | 30.06 | 43.10 | | 13.04 |
| ι Cephei | | 47 | 12.04 | −0.53 | −0.48 | 11.03 | 23.84 | [12.81] | |
| β Pegasi | | 59 | 42.84 | −0.12 | −0.23 | 42.49 | 55.52 | | 13.08 |
| 56 Pegasi | 23 | 3 | 1.40 | −0.11 | −0.22 | 1.07 | 14.21 | 13.14 | |
| π Cephei | | 5 | 53.62 | −0.88 | −0.76 | 51.98 | 5.29 | | [13.31] |
| 130 Heis Pegasi | | 11 | 48.24 | −0.11 | −0.22 | 47.91 | 1.06 | 13.15 | |

The chronometer used was Negus 1481; the transit instrument, Würdemann 31; its line-intervals from the center, $3^s.538n$, where $n$ is a whole number less than 15. The lines were ruled on glass, 25 in number, in 5 groups; I could detect no deviation from regularity in them, and always employed symmetrical lines. The value of one level division used was 1″.0; later Mr. Rock found 0″.977.

The personal equation with Mr. Rock was determined by means of a personal equation apparatus. Its value will be found in the report on the longitude of Fort Bliss. This also was neglected; it was too uncertain.

The calculations of latitude for the different stations were made with the help of the catalogue of 2,018 stars. Stars outside of its range were taken from the American Ephemeris as now corrected; that is, applying to the apparent places of the volume for 1878 the corrections given in that for 1881; or from the German catalogue of 539 stars, using the last revision of its places; when a star occurs in both these catalogues, a mean was taken.

For other stars the most modern authorities were reduced, after the manner of the catalogue of 2,018 stars. In a very few cases no accurate place of the star could be found; this refers chiefly to such stars in the new Coast Survey rough-working list as had not been observed of late years, and had been excluded from the catalogue of 2,018 stars for that reason.

Whenever the result of all the observations upon a pair or combination of stars seemed discrepant, the declinations were thoroughly revised. No correction was found in this way to the catalogue of 2,018 stars; in some cases new observations have been lately published, but no star was found to need any correction which could sensibly affect the results.

The combinations of more than two stars gave some trouble. In one case there are three north stars and four south, which would give twelve pairs, but with a weight of $\frac{2.3.4}{3+4}=3\frac{3}{7}$ only. In this and all similar cases I treated the whole combination as one pair; that is, I inserted in the blank provided the half sum of the mean of the declinations of north stars, and of the mean of the declinations of south stars, and gave the result a higher weight. This is the only logical method. Of course in all these cases I took pains to see that the micrometer readings were such as agreed with the known differences of declinations of the stars, before taking the means.

The notes upon the stations were prepared by the observers.

I remain, sir, very respectfully, yours,

T. H. SAFFORD.

Capt. G. M. WHEELER,
*United States Engineers, in charge.*

## ASTRONOMICAL STATION AT WALLA WALLA, WASH. TER., 1878.

### GEOGRAPHICAL POSITION.

Latitude 46° 3′ 55.″89.

Longitude —— ——— ———.

Barometric altitude of observatory above sea level (monument), 1,033.5 feet.

In reducing the observations for time made at Walla Walla discrepancies were found which could not be explained for lack of time. The discussion of the longitude is here omitted.

The pier, of cemented brick, from which the observations were made for the astronomical determination of this station, is situated in block No. 9, known as jail-square, 57 feet from the center of Fifth street, and 211 feet in a straight line to a street monument in the center of Main and Fifth streets (see plate herewith). The location was objectionable on account of dust, smoke, jar and noise, but was unavoidable, there being no other place where the pier would probably be protected, and at the same time afford the necessary telegraphic facilities.

In erecting the pier the magnetic needle, variation 20¼° east, was used; the transit, however, showed it to be largely out of the prime vertical. The unreliability of the needle in this instance is due, doubtless, to the components of the soil, which is here constituted largely of bowlders charged with magnetic iron.

### WALLA WALLA AND ITS SURROUNDINGS.

Wallula is a clear, rapid creek heading in the Blue Mountains and running westward to the Columbia River. In a dish-shaped valley and some 30 miles from the mountain lies Walla Walla, on both sides of the creek. Its population is some 3,000. It is a place of large business in all branches of trade, and is the objective point for the torrent of emigration at present heading for the Pelouse County.

By irrigation the soil gives evidence of great fertility, producing not only small grain but the best of all sorts of vegetables and the finest corn, probably, west of the Mississippi Valley. Fruit is also in abundance, of fine quality, not only apples, pears, and the like, but also grapes. The city is regularly laid out, and both as to extent of squares and ornamentation is not unlike the best settlements of Mormondom. The streets are planted with Lombardy poplars, which have made a rapid growth and contribute much both to the appearance and the comfort of the place. They have been irrigated up to the present time, but it is believed that they will eventually root deeply enough in the loose soil to secure sufficient moisture.

### METEOROLOGICAL CONDITIONS.

Three weeks were occupied in the determination, in latitude and longitude, of this station, from August 8 to August 29. There were many electrical phenomena and some clouds to occasion delay, but there was no rain, nor had there been any to bless this land of dust since the March previous.

Observations were made August 10, 12, 13, 14, 16, 18, 19, 24, and 25. The 15th, 17th, 20th, 21st, 22d, and 23d were cloudy—a week out of three, yet no rain. The night of August 22, while loitering at the observatory tent, waiting for the clouds to disperse, a "chinook" was felt, but it was of brief duration. The "chinook" is a hot wind that comes from the sea; it is common in winter, and is particularly remarkable for the rapidity of its softening action upon the snow and the frost-locked land.

### TELEGRAPHIC COMMUNICATION.

The connection was made with the Ogden Observatory by way of Boise City and Winnemucca. That portion of the line between Walla Walla and Winnemucca was in charge of Professor Speed, it having been but recently put in order for military purposes. It was a perpetual source of delay and worry; men had to be kept out constantly looking after it. The poles were rotten and gave way daily from one cause or another and the wire was seldom or never working 12 hours consecutively.

Length of circuit about 989 miles.

### METHOD OF OBSERVATION.

Observations were made with eye and ear, Mr. G. M. Dunn recording, and giving other efficient service in addition to his meteorological observations. The chronometer for exchange of signals was taken to the telegraphic office, distant some three squares.

### INSTRUMENTS.

Z. M. (Würdemann, No. 16). This instrument is old and much worn, and if at its best would be too small for latitude work in the atmosphere of Walla Walla.

Chronometer Negus No. 1511 was used and had a very fair rate, despite the necessarily rough usage it received in the stage trip from Redding to Roseburg.

*Wire-intervals (Lamp east).*

| | |
|---|---|
| 1–3, | 43.61 |
| 2–3, | 21.87 |
| 3–4, | 21.29 |
| 3–5, | 43.53 |

| | | |
|---|---|---|
| One division of striding-level | 1.″14 | |
| One division of zenith telescope-level | 1.″44 | |
| One revolution of micrometer: | | |
| Assumed, including refraction | 81.″00 | |
| Corrected after discussion by | 0.″1215* | |
| | 80.″8785 | |
| Subtract refraction | 0.″025 | |
| Final value | 80.″85 | nearly. |

*—0.″09 for every minute.

***Mean place of stars for* 1878.0 *used for the determination of latitude of Walla Walla, Wash.***

| No. of pair. | No. B. A. C. | Class. | R. A. h. | m. | s. | Declination. ° | ′ | ″ |
|---|---|---|---|---|---|---|---|---|
| | 5840 | A | 17 | 11 | 30 | 63 | 0 | 49.7 |
| | (1) | C | 17 | 14 | 0 | 28 | .57 | 4.9 |
| | 5874 | B | 17 | 17 | 43 | 40 | 5 | 42.5 |
| | 5937 | A A | 17 | 27 | 41 | 52 | 23 | 32.5 |
| | 5972 | A | 17 | 32 | 27 | 68 | 12 | 45.0 |
| | 6005 | A | 17 | 38 | 21 | 24 | 22 | 55.4 |
| | 5975 | B | 17 | 33 | 26 | 48 | 39 | 26.4 |
| | 6013 | C | 17 | 39 | 29 | 44 | 8 | 18.3 |
| | (2) | C | 17 | 48 | 38 | 46 | 40 | 32.7 |
| | (3) | C | 17 | 53 | 13 | 45 | 22 | 2.2 |
| | (4) | C | 17 | 55 | 23 | 45 | 29 | 8.3 |
| | 6109 | B | 17 | 56 | 27 | 45 | 30 | 28.2 |
| | 6162 | C | 18 | 3 | 48 | 43 | 26 | 52.5 |
| | (5) | C | 18 | 11 | 50 | 49 | 6 | 54.4 |
| | 6218 | B | 18 | 13 | 15 | 40 | 53 | 22.2 |
| | 6246 | B | 18 | 17 | 5 | 51 | 17 | 41.5 |
| | 6258 | C | 18 | 18 | 37 | 51 | 14 | 33.5 |
| | 6252 | B | 18 | 18 | 4 | 49 | 39 | 59.5 |
| | (6) | B | 18 | 20 | 24 | 42 | 24 | 7.0 |
| | (7) | C | 18 | 21 | 34 | 26 | 23 | 24.7 |
| | (8) | C | 18 | 21 | 46 | 26 | 22 | 42.2 |
| | 6316 | A | 18 | 25 | 38 | 65 | 29 | 16.8 |
| | (13) | C | 18 | 30 | 52 | 65 | 20 | 19.3 |
| | (9) | A | 18 | 35 | 50 | 65 | 22 | 45.9 |
| | (10) | B | 18 | 39 | 12 | 39 | 10 | 43.1 |
| | 6390 | A | 18 | 40 | 18 | 39 | 32 | 35.9 |
| | 6391 | A | 18 | 40 | 20 | 39 | 29 | 9.0 |
| | 6419 | A | 18 | 43 | 59 | 52 | 51 | 16.6 |
| | 6452 | B | 18 | 48 | 51 | 52 | 49 | 4.2 |
| | (14) | C | 18 | 51 | 24 | 40 | 1 | 12.5 |
| | 6493 | C | 18 | 54 | 47 | 40 | 30 | 45.8 |
| | (15) | C | 18 | 56 | 19 | 40 | 30 | 49.1 |
| | 6530 | C | 18 | 59 | 15 | 52 | 5 | 5.0 |
| | 6551 | B | 19 | 2 | 11 | 53 | 12 | 35.4 |
| | 6581 | A | 19 | 9 | 36 | 38 | 56 | 12.7 |
| | 6629 | C | 19 | 15 | 41 | 62 | 59 | 10.4 |
| | 6648 | B | 19 | 19 | 19 | 29 | 23 | 1.9 |
| | 6681 | C | 19 | 23 | 34 | 57 | 46 | 55.2 |
| | 6698 | A | 19 | 27 | 14 | 34 | 11 | 40.3 |
| | (11) | C | 19 | 28 | 39 | 55 | 28 | 21.5 |
| | 6722 | A | 19 | 31 | 25 | 36 | 40 | 29.6 |
| | 6748 | B | 19 | 35 | 57 | 54 | 41 | 15.8 |
| | 6771 | A | 19 | 39 | 53 | 37 | 3 | 37.7 |
| | 6780 | C | 19 | 40 | 52 | 57 | 43 | 33.9 |
| | 6777 | B | 19 | 41 | 19 | 34 | 42 | 59.2 |
| | 6779 | A A | 19 | 41 | 10 | 44 | 50 | 1.5 |
| | 6799 | C | 19 | 43 | 53 | 47 | 36 | 24.6 |
| | 6810 | A | 19 | 45 | 49 | 22 | 18 | 3.7 |
| | 6836 | A A | 19 | 48 | 35 | 69 | 57 | 25.7 |
| | 6879 | A | 19 | 56 | 5 | 27 | 25 | 2.9 |
| | 6905 | A | 20 | 0 | 11 | 64 | 28 | 46.0 |
| | 6930 | C | 20 | 3 | 12 | 63 | 32 | 23.0 |
| | 6957 | A | 20 | 9 | 14 | 28 | 19 | 34.2 |
| | 6990 | A | 20 | 13 | 17 | 37 | 39 | 15.5 |
| | 7035 | C | 20 | 19 | 52 | 54 | 16 | 48.4 |
| | 7055 | C | 20 | 22 | 23 | 54 | 17 | 7.2 |
| | 7098 | A | 20 | 27 | 32 | 62 | 35 | 3.5 |
| | 7152 | A | 20 | 33 | 58 | 29 | 54 | 28.7 |
| | 7166 | C | 20 | 35 | 51 | 55 | 34 | 32.4 |
| | 7213 | A A | 20 | 42 | 39 | 36 | 2 | 35.2 |
| | 7297 | A | 20 | 55 | 15 | 39 | 46 | 34.9 |
| | 7332 | C | 21 | 0 | 4 | 52 | 48 | 1.8 |
| | 7401 | B | 21 | 13 | 35 | 55 | 17 | 9.5 |
| | 7462 | A | 21 | 22 | 23 | 36 | 35 | 14.0 |
| | 7483 | C | 21 | 26 | 17 | 52 | 25 | 17.4 |
| | 7489 | C | 21 | 27 | 21 | 52 | 4 | 55.6 |
| | 7521 | A | 21 | 32 | 3 | 39 | 51 | 57.7 |
| | 7555 | C | 21 | 36 | 41 | 54 | 19 | 4.2 |
| | 7566 | A | 21 | 38 | 23 | 37 | 43 | 32.5 |
| | (12) | B | 21 | 38 | 34 | 37 | 44 | 50.3 |
| | 7614 | B | 21 | 46 | 2 | 38 | 57 | 57.5 |
| | 7637 | A | 21 | 49 | 3 | 53 | 25 | 21.7 |
| | 7696 | A | 21 | 59 | 56 | 59 | 13 | 24.2 |
| | 7698 | B | 22 | 0 | 14 | 59 | 16 | 31.8 |
| | 7721 | A | 22 | 3 | 49 | 32 | 34 | 36.4 |
| | 7731 | A | 22 | 4 | 34 | 32 | 34 | 47.9 |
| | 7746 | B | 22 | 6 | 26 | 50 | 13 | 15.2 |
| | 7770 | C | 22 | 9 | 37 | 42 | 20 | 58.3 |

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[1] Sd. 645.
[2] Sd. 714.
[3] Gr. 2491.
[4] Sd. 726.
[5] Sd. 754.
[6] Sd. 779.
[7] Sd. 781.
[8] Sd. 782.
[9] Sd. 804.
[10] Sd. 812.
[11] Sd. 956.
[12] Sd. 1364.
[13] Gr. 2617.
[14] Gr. 2715.
[15] Gr. 2735.

*Observations and computations for latitude, Walla Walla, Wash.*

| Date. | Number of star. | Micrometer readings. | Level. N. | Level. S. | Half sum of declination. | Corrections. Micr. and refr. | Corrections. Level. | Corrections. Merid. | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | ° ′ ″ | ′ ″ | ″ | | ° ′ ″ |
| August 13, 1878........ | 6551<br>6581 | 5.595<br>5.200 | 9<br>22 | 26<br>13 | 46 4 34.8 | − 0 12.0 | −3.6 | ........ | 46 4 15.2 |
| | 6629<br>6648 | 14.005<br>3.545 | 17<br>13 | 18<br>22 | 46 11 16.9 | − 7 3.6 | −4.5 | ........ | 4 8.8 |
| | (11)<br>6722 | 8.415<br>7.530 | 10<br>13 | 16.5<br>23 | 46 4 36.9 | − 35.8 | −3.4 | ........ | 3 57.7 |
| | 6748<br>6771 | *−1.115<br>16.980 | 20<br>12 | 16<br>24 | 45 52 38.4 | +11 23.0 | −3.6 | ........ | 3 57.8 |
| | 6810<br>6836 | 3.835<br>9.610 | 14<br>18 | 22<br>18 | 46 7 55.8 | − 3 53.9 | −3.6 | ........ | 3 58.3 |
| | 6930<br>6957 | 0.850<br>12.465 | 20<br>...... | 16<br>...... | 45 56 10.7 | + 7 50.4 | −3.7 | ........ | 3 57.4 |
| August 14, 1878........ | 5840<br>(1) | 5.755<br>12.885 | 16.5<br>16.5 | 16<br>16 | 45 59 3.4 | + 4 48.8 | +0.4 | ........ | 3 52.6 |
| | 5874<br>5937 | 0.240<br>16.320 | 18<br>16 | 14<br>17 | 46 14 44.6 | −10 51.2 | +1.1 | ........ | 3 54.5 |
| | 5975<br>6013 | 30.855<br>1.085 | 14<br>20 | 20<br>13 | 46 24 0.21 | −20 5.7 | +0.4 | ........ | 3 54.9 |
| | (2)<br>(3)<br>(4)<br>6109 | 16.110<br>19.790<br>14.535<br>13.490 | 17<br>......<br>......<br>18 | 17<br>......<br>......<br>16 | 46 4 0.4 | − 7.0 | +0.7 | ........ | 3 54.1 |
| | 6162<br>(5) | 2.895<br>22.340 | 18<br>16.5 | 16<br>17 | 46 17 2.5 | −13 7.5 | +0.5 | ........ | 3 55.5 |
| | 6391<br>6419<br>6452 | 7.680<br>17.305<br>15.650 | 21.5<br>14<br>...... | 13<br>20<br>...... | 46 9 50.0 | − 5 56.3 | +0.9 | ........ | 3 54.6 |
| | 6551<br>6581 | 13.690<br>12.710 | 21<br>15 | 14<br>20 | 46 4 35.1 | − 39.7 | +0.7 | ........ | 3 56.1 |
| | 6629<br>6648 | 18.540<br>7.575 | 20<br>16 | 15<br>18.5 | 46 11 17.1 | − 7 24.1 | +0.9 | ........ | 3 53.9 |
| | 6681<br>6698 | 12.390<br>18.960 | 20<br>18 | 15<br>17 | 45 59 29.2 | + 4 26.1 | +2.2 | ........ | 3 57.5 |
| | 6748<br>6771 | 8.200<br>24.835 | 21.5<br>15.5 | 14<br>19.5 | 45 52 38.7 | +11 13.7 | +1.3 | ........ | 3 53.7 |
| | 6779<br>6799 | 10.940<br>24.960 | 10.5<br>25 | 25.0<br>15 | 46 13 25.2 | − 9 27.8 | +0.2 | ........ | (?) 3 57.6† |
| | 6879<br>6905 | 22.200<br>12.050 | 15<br>21.5 | 20<br>14 | 45 57 6.5 | + 6 51.1 | +0.9 | ........ | 3 58.5 |
| | 6930<br>6957 | 16.560<br>28.050 | 17<br>20 | 18.5<br>16 | 45 56 11.0 | + 7 45.3 | +0.9 | ........ | 3 57.2 |
| | 6990<br>7035<br>7055 | 18.365<br>9.945<br>10.155 | 17<br>22<br>...... | 19<br>14<br>...... | 45 58 19.5 | + 5 36.8 | +2.2 | ........ | 3 58.5 |
| | 7098<br>7152 | 23.545<br>9.120 | 21.5<br>17 | 14<br>18.5 | 46 14 59.1 | −11 5.2 | +2.2 | ........ | 3 56.1 |
| August 17, 1878........ | 6551<br>6581 | 13.320<br>12.330 | 21<br>18 | 18<br>21 | 46 4 35.8 | − 40.1 | 0.0 | ........ | 3 55.7 |
| | 6629<br>6648 | 19.998<br>9.065 | 20<br>19 | 18<br>20 | 46 11 17.8 | − 7 22.8 | +0.4 | ........ | 46 3 55.4 |

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* Should be 0.115.

There is a manifest error in the level reading. I have conjectured 25 10 to be the proper numbers for 6799 S.

[3] Sd. 714. [5] Sd. 754. [6] Sd. 779. [10] Sd. 812. [11] Sd. 956.

*Observations and computations for latitude, Walla Walla, Wash. Ter.*—**Continued.**

| Date. | Number of star. | Micrometer readings. | Level. |  | Half sum of declination. | Corrections. |  |  | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | N. | S. |  | Micr. and refr. | Level. | Merid. |  |
|  |  |  |  |  | ° ′ ″ | ′ ″ | ″ |  | ° ′ ″ |
| August 17, 1878........ | 6681 | 9.478 | 22 | 17 | 45 59 30.0 | + 4 27.4 | +0.2 | ........ | 46 3 57.6 |
|  | 6698 | 16.080 | 17.5 | 22 |  |  |  |  |  |
|  | 6748 | 7.900 | 24 | 15 | 45 52 39.5 | +11 17.2 | −0.7 | ........ | 3 56.0 |
|  | 6771 | 24.620 | 14 | 25 |  |  |  |  |  |
|  | 6810 | 11.558 | 15 | 24 | 46 7 56.9 | − 4 3.1 | 0.0 | ........ | 3 53.8 |
|  | 6836 | 17.560 | 24 | 15 |  |  |  |  |  |
|  | 6879 | 20.230 | 13.5 | 25 | 45 57 7.3 | + 6 50.1 | +4.1 | ........ | 61.5 |
|  | 6905 | 10.105 | 30 | 7 |  |  |  |  |  |
| August 18, 1878........ | 5972 | 24.335 | 22 | 15 | 46 17 57.5 | −14 4.8 | −0.4 | ........ | 3 52.3 |
|  | 6005 | 3.475 | 14 | 22 |  |  |  |  |  |
|  | (2) | 18(?).255 | 18 | 18 | 46 5 39.5 | − 1 45.1 | −0.2 | ........ | 3 54.2 |
|  | 6109 | 10(?).660 | 18 | 18.5 |  |  |  |  |  |
|  | 6162 | 5.215 | 16.5 | 20 | 46 17 3.2 | −13 10.2 | −0.9 | ........ | 3 52.1 |
|  | (5) | 25(?).725 | 19 | 18 |  |  |  |  |  |
|  | 6252 | 15.860 | 21.5 | 16 | 46 2 13.5 | + 1 7.4 | −0.2 | ........ | 3 [20.7] |
|  | (6) | 17.525 | 15.5 | 21.5 |  |  |  |  |  |
|  | (10) | 21.710 | ...... | ...... | 46 7 21.0 | − 3 25.4 | +0.4 | ........ | 3 56.0 |
|  | 6391 | 8.060 | ...... | ...... |  |  |  |  |  |
|  | 6390 | 5.475 | 15.5 | 21.5 |  |  |  |  |  |
|  | 6419 | 17.690 | 22 | 15 |  |  |  |  |  |
|  | 6452 | 15.950 | ...... | ...... |  |  |  |  |  |
|  | 6493 | 3.515 | 15 | 22 | 46 18 7.1 | −14 14.8 | −0.2 | ........ | 3 52.1 |
|  | 6530 | 24.620 | 22 | 15.5 |  |  |  |  |  |
|  | 6551 | 12.350 | 19.5 | 18 | 46 4 36.0 | − 0 41.7 | +0.7 | ........ | 3 55.0 |
|  | 6581 | 11.320 | 19 | 18.5 |  |  |  |  |  |
|  | 6629 | 18.320 | 23.5 | 14 | 46 11 18.1 | − 7 20.6 | 0.0 | ........ | 3 57.5 |
|  | 6648 | 7.440 | 14 | 23.5 |  |  |  |  |  |
|  | 6681 | 8.275 | 19 | 18.5 | 45 59 30.2 | + 4 25.3 | +0.5 | ........ | 3 56.0 |
|  | 6698 | 14.825 | 19 | 18 |  |  |  |  |  |
|  | (11) | 11.750 | 21 | 17 | 46 4 38.3 | − 0 43.7 | +1.1 | ........ | 3 55.7 |
|  | 6722 | 10.670 | 18 | 19 |  |  |  |  |  |
|  | 6748 | 4.650 | 21 | 16.5 | 45 52 39.8 | +11 13.1 | +0.5 | ........ | 3 53.4 |
|  | 6771 | 21.270 | 17 | 20 |  |  |  |  |  |
|  | 6780 | 12.170 | ...... | ...... | 46 13 29.5 | − 9 33.9 | +0.5 | ........ | 3 56.1 |
|  | 6777 | 26.340 | ...... | ...... |  |  |  |  |  |
|  | 6810 | 15.620 | 15.5 | 22 | 46 7 57.1 | − 4 2.6 | +1.3 | ........ | 3 55.8 |
|  | 6836 | 21.610 | 24 | 14 |  |  |  |  |  |
|  | 6879 | 21.965 | 16 | 21 | 45 57 7.6 | + 6 50.5 | −0.4 | ........ | 3 57.7 |
|  | 6905 | 11.830 | 21 | 17 |  |  |  |  |  |
|  | 6930 | 12.380 | 20 | 18 | 45 56 12.1 | + 7 45.3 | 0.0 | ........ | 3 57.4 |
|  | 6957 | 23.870 | 18 | 20 |  |  |  |  |  |
|  | 6990 | 21.138 | 15.5 | 22 | 45 58 20.7 | + 5 37.9 | +1.3 | ........ | 3 59.9 |
|  | 7035 | 12.705 | 24 | 14 |  |  |  |  |  |
|  | 7055 | 12.885 | ...... | ...... |  |  |  |  |  |
|  | 7098 | 26.475 | 21 | 18 | 46 15 0.2 | −11 4.8 | +0.4 | ........ | 3 55.8 |
|  | 7152 | 10.060 | 18 | 20 |  |  |  |  |  |
|  | 7166 | 0.885 | 22 | 16.5 | 45 48 48.4 | +15 10.6 | −0.2 | ........ | 3 58.8 |
|  | 7213 | 23.370 | 16 | 22 |  |  |  |  |  |
|  | 7297 | 4.245 | 17 | 21 | 46 17 33.3 | −13 37.5 | −0.5 | ........ | 3 55.3 |
|  | 7332 | 26.430 | 20.5 | 18 |  |  |  |  |  |
|  | 7401 | 7.905 | 22 | 16.5 | 45 56 27.0 | + 7 30.4 | +0.4 | ........ | 46 3 57.8 |
|  | 7462 | 19.025 | 17 | 21.5 |  |  |  |  |  |

*Observations and computations for latitude, Walla Walla, Wash. Ter.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. | | Half sum of declination. | Corrections. | | | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
| | | | N. | S. | | Micr. and refr. | Level. | Merid. | |
| | | | | | ° ′ ″ | ′ ″ | ″ | | ° ′ ″ |
| August 18, 1878........ | 7483 | 21.700 | ...... | ...... | 46 3 47.5 | + 0 7.7 | +0.5 | ........ | 46 3 55.7 |
| | 7489 | 6.575 | 21 | 18 | | | | | |
| | 7521 | 14.328 | 18.5 | 20 | | | | | |
| | 7555 | 16.785 | 22 | 16.5 | 46 1 33.8 | + 2 22.2 | +1.3 | ........ | 3 57.3 |
| | 7566 | 20.295 | 18 | 20 | | | | | |
| | 7614 | 9.720 | 18 | 20 | 46 11 55.1 | − 7 57.3 | −0.7 | ........ | 3 57.1 |
| | 7637 | 21.505 | 19.5 | 19.5 | | | | | |
| | 7696 | 5.830 | ...... | ...... | 45 54 15.8 | + 9 38.7 | +0.1 | ........ | 3 54.6 |
| | 7698 | 6.105 | ...... | ...... | | | | | |
| | 7721 | 19.120 | ...... | ...... | 45 55 55.4 | + 7 59.9 | +0.1 | ........ | 3 55.4 |
| | 7731 | 18.955 | ...... | ...... | | | | | |
| | 7746 | 31.015 | 18 | 21 | 46 17 23.8 | −13 20.5 | +0.9 | ........ | 64.2 |
| | 7770 | 11.250 | 22 | 16.5 | | | | | |
| August 20, 1878........ | (10) | 24.130 | ...... | ...... | 46 7 21.4 | − 3 24.6 | +0.5 | ........ | 3 57.3 |
| | 6391 | 10.440 | ...... | ...... | | | | | |
| | 6390 | 7.880 | 16.5 | 20 | | | | | |
| | 6419 | 20.020 | 21 | 16 | | | | | |
| | 6452 | 18.385 | ...... | ...... | | | | | |
| | 6990 | 18.090 | 15 | 22.5 | 45 58 21.3 | + 5 38.7 | +0.9 | ........ | 60.9 |
| | 7035 | 9.660 | 24 | 14 | | | | | |
| | 7055 | 9.895 | ...... | ...... | | | | | |
| | 7098 | 20.978 | 21.5 | 16.5 | 46 15 0.8 | −11 6.3 | −0.2 | ........ | 3 54.3 |
| | 7152 | 4.525 | 16 | 21.5 | | | | | |
| | 7297 | 3.465 | 16.5 | 21.5 | 46 17 33.9 | −13 41.3 | +0.4 | ........ | 3 53.0 |
| | 7332 | 23.745 | 22 | 16 | | | | | |
| | 7401 | 7.635 | 21 | 17.5 | 45 56 27.6 | + 7 28.5 | +0.5 | ........ | 3 56.6 |
| | 7462 | 18.710 | 18 | 20 | | | | | |
| | 7483 | 22.710 | ...... | ...... | 46 3 48.1 | + 0 9.5 | −0.4 | ........ | 3 57.2 |
| | 7489 | 7.580 | 23 | 16 | | | | | |
| | 7521 | 15.380 | 15 | 23 | | | | | |
| | 7555 | 12.970 | 24.5 | 14 | 46 1 53.9 | + 2 3.1 | 0.0 | ........ | 3 57.0 |
| | 7566 | 16.470 | ...... | ...... | | | | | |
| | (12) | 15.550 | 14 | 24.5 | | | | | |
| | 7614 | 7.390 | 16.5 | 22 | 46 11 55.8 | − 8 3.3 | +0.7 | ........ | 3 53.2 |
| | 7637 | 19.323 | 23. | 15.5 | | | | | |
| | 7696 | 5.145 | ...... | ...... | 45 54 16.5 | + 9 38.9 | +0.5 | ........ | 3 55.9 |
| | 7698 | 7.380 | ...... | ...... | | | | | |
| | 7721 | 19.440 | ...... | ...... | 45 55 56.1 | + 8 3.6 | +0.5 | ........ | 60.2 |
| | 7731 | 19.320 | ...... | ...... | | | | | |
| | 7746 | 22.940 | 20.5 | 18. | 46 17 24.4 | −13 28.0 | +0.4 | ........ | 3 56.8 |
| | 7770 | 2.990 | 18 | 18.5 | | | | | |
| August 21, 1878........ | 7098 | 23.425 | 22.5 | 16.5 | 46 15 1.1 | −11 1.0 | −4.0 | ........ | 3 56.1 |
| | 7152 | 7.105 | 11 | 28 | | | | | |
| | 7166 | 2.385 | 22.5 | 16.5 | 45 48 49.3 | +15 12.0 | −4.0 | ........ | 3 57.3 |
| | 7213 | 24.903 | 11 | 28 | | | | | |
| | 7297 | 3.715 | 15.5 | 24 | 46 17 34.3 | −13 40.9 | −2.0 | ........ | 3 51.4 |
| | 7332 | 23.985 | 21 | 18 | | | | | |
| | 7401 | 8.035 | 23 | 17 | 45 56 28.0 | + 7 28.7 | −0.9 | ........ | 3 55.8 |
| | 7462 | 19.115 | 15.5 | 24 | | | | | |
| | 7483 | 23.400 | ...... | ...... | 46 3 48.4 | + 0 8.1 | −1.8 | ........ | 3 54.7 |
| | 7489 | 8.290 | 21.5 | 18 | | | | | |
| | 7521 | 16.045 | 15.5 | 24 | | | | | |
| | 7555 | 15.355 | 21 | 18 | 46 1 34.8 | + 2 22.6 | −3.1 | ........ | 46 3 54.3 |
| | 7566 | 18.875 | 14 | 25.3 | | | | | |

*Observations and computations for latitude, Walla Walla, Wash. Ter.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. |  | Half sum of declination. | Corrections. |  |  | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | N. | S. |  | Micr. and refr. | Level. | Merid. |  |
|  |  |  |  |  | ° ′ ″ | ′ ″ | ″ |  | ° ′ ″ |
| August 21, 1878........ | 7614 | 12.225 | 18 | 21 | 46 11 56.1 | − 7 57.9 | −3.4 | ........ | 46 3 54.8 |
|  | 7637 | 24.025 | 16.5 | 23 |  |  |  |  |  |
|  | 7696 | 9.810 | ...... | ...... | 45 54 16.8 | + 9 41.6 | [−3.2] | ........ | 3 55.2 |
|  | 7698 | 12.175 | 22 | 18 |  |  |  |  |  |
|  | 7721 | 24.170 | ...... | ...... | 45 55 56.4 | + 7 58.9 | [−3.2] | ........ | 3 52.1 |
|  | 7731 | 24.000 | ...... | ...... |  |  |  |  |  |
| August 23, 1878........ | 5874 | 4.050 | 12.5 | 19 | 46 14 45.7 | −10 53.9 | +4.1 | ........ | 3 55.9 |
|  | 5937 | 20.195 | 24 | 8 |  |  |  |  |  |
|  | 5972 | 27.630 | 19 | 13 | 46 17 58.1 | −14 6.2 | +1.6 | ........ | 3 53.5 |
|  | 6005 | 6.760 | 15.5 | 17 |  |  |  |  |  |
|  | (2) | 18.355 | 16 | 17 | 46 4 1.8 | − 0 9.2 | +2.9 | ........ | 3 55.5 |
|  | (3) | 22.945 | 6 | ...... |  |  |  |  |  |
|  | (4) | 16.750 | ...... | ...... |  |  |  |  |  |
|  | 6109 | 15.690 | 21 | 12 |  |  |  |  |  |
|  | 6162 | 11.355 | 15.5 | 18 | 46 17 4.1 | −13 12.4 | +2.0 | ........ | 3 53.7 |
|  | (5) | 28.920 | 20.5 | 12.5 |  |  |  |  |  |
|  | 6218 | 15.415 | 14 | 19 | 46 4 8.8 | − 0 16.8 | +1.4 | ........ | 3 53.4 |
|  | 6258 | 15.830 | 21.5 | 12.5 |  |  |  |  |  |
|  | (8) | 22.160 | 14.5 | 19 | 45 52 54.7 | +11 2.0 | +3.2 | ........ | 3 59.9 |
|  | (9) | 5.813 | 24 | 10.5 |  |  |  |  |  |
|  | (10) | 22.220 | ...... | ...... | 46 7 22.0 | − 3 31.1 | [+3.0] | ........ | 3 53.9 |
|  | 6390 | 8.530 | ...... | ...... |  |  |  |  |  |
|  | 6391 | 5.975 | ...... | ...... |  |  |  |  |  |
|  | 6419 | 18.268 | 24 | 11 |  |  |  |  |  |
|  | 6452 | 16.640 | ...... | ...... |  |  |  |  |  |
|  | 6780 | 8.825 | ...... | ...... | 46 13 30.8 | − 9 41.0 | [+3.0] | ........ | 3 52.8 |
|  | 6777 | 23.170 | ...... | ...... |  |  |  |  |  |
|  | 6810 | 9.130 | 15 | 20 | 46 7 58.3 | − 4 7.9 | +3.2 | ........ | 3 53.6 |
|  | 6836 | 16.250 | 25 | 11 |  |  |  |  |  |
|  | 6879 | 21.240 | 13.5 | 22 | 45 57 8.8 | + 6 44.2 | +3.1 | ........ | 3 56.1 |
|  | 6905 | 16.260 | 26 | 9 |  |  |  |  |  |
|  | 6930 | 12.828 | 19 | 16.5 | 45 56 13.4 | + 7 40.6 | +3.4 | ........ | 3 57.4 |
|  | 6957 | 24.200 | 21 | 14 |  |  |  |  |  |
|  | 6990 | 24.715 | 14.5 | 20.5 | 45 58 22.2 | + 5 29.8 | +1.4 | ........ | 3 53.4 |
|  | 7035 | 16.455 | 25 | 15 |  |  |  |  |  |
|  | 7055 | 69.690 | ...... | ...... |  |  |  |  |  |
|  | 7098 | 25.010 | 21 | 15 | 46 15 1.7 | −11 10.5 | +3.4 | ........ | 3 54.6 |
|  | 7152 | 9.455 | 19 | 15.5 |  |  |  |  |  |
|  | 7166 | 6.115 | 18 | 18 | 45 48 50.1 | +15 3.1 | +3.4 | ........ | 3 56.6 |
|  | 7213 | 28.413 | 22.5 | 13 |  |  |  |  |  |
|  | 7297 | 5.670 | 16 | 20 | 46 17 34.9 | −13 43.9 | +2.9 | ........ | 3 53.9 |
|  | 7332 | 26.013 | 24 | 12 |  |  |  |  |  |
|  | 7401 | 9.480 | 20.5 | 15 | 45 56 28.6 | + 7 24.5 | +3.2 | ........ | 3 56.3 |
|  | 7462 | 20.455 | 19.5 | 16 |  |  |  |  |  |
|  | 7483 | 24.173 | ...... | ...... | 46 3 49.1 | + 0 1.2 | +3.4 | ........ | 3 53.7 |
|  | 7489 | 9.050 | 20 | 16 |  |  |  |  |  |
|  | 7521 | 16.640 | 20.5 | 15 |  |  |  |  |  |
|  | 7555 | 15.790 | 24 | 12 | 46 1 35.4 | + 2 16.9 | +3.2 | ........ | 3 55.5 |
|  | 7566 | 19.170 | 16.5 | 19.5 |  |  |  |  |  |
|  | 7614 | 9.620 | 18 | 18 | 46 11 56.7 | − 8 6.6 | +4.1 | ........ | 3 54.2 |
|  | 7637 | 21.635 | 24 | 12.5 |  |  |  |  |  |
|  | 7698 | 11.490 | 21 | 15 | 45 55 54.1 | +7 57.5 | +3.4 | ........ | 46 3 55.0 |
|  | 7721 | 23.358 | 20 | 16.5 |  |  |  |  |  |
|  | 7731 | 23.200 | ...... | ...... |  |  |  |  |  |

*Observations and computations for latitude, Walla Walla, Wash. Ter.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. |  | Half sum of declination. | Corrections. |  |  | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | N. | S. |  | Micr. and refr. | Level. | Merid. |  |
|  |  |  |  |  | ° ′ ″ | ′ ″ | ″ |  | ° ′ ″ |
| August 23, 1878 | 7746 | 27.055 | 24 | 12.5 | 46 17 25.2 | −13 34.1 | +3.1 | ........ | 46 3 54.2 |
|  | 7770 | 6.953 | 16.5 | 19.5 |  |  |  |  |  |
| August 24, 1878 | 6218 | 14.375 | 18 | 14 | 46 4 55.9 | − 1 1.0 | +2.2 | ........ | 3 57.1 |
|  | 6246 | 17.050 | ...... | ...... |  |  |  |  |  |
|  | 6258 | 14.710 | 18 | 16 |  |  |  |  |  |
|  | (7) | 21.180 | ...... | ...... | 45 53 47.6 | +10 7.0 | +2.5 | ........ | 3 57.1 |
|  | (8) | 21.680 | 15.5 | 18 |  |  |  |  |  |
|  | 6316 | 10.250 | ...... | ...... |  |  |  |  |  |
|  | (13) | 3.725 | 22 | 12.5 |  |  |  |  |  |
|  | (9) | 5.355 | ...... | ...... |  |  |  |  |  |
|  | (10) | 22.750 | ...... | ...... | 46 7 22.2 | − 3 29.9 | +3.6 | ........ | 3 55.9 |
|  | 6391 | 9.070 | ...... | ...... |  |  |  |  |  |
|  | 6390 | 7.455 | 14 | 80 |  |  |  |  |  |
|  | 6419 | 18.755 | 25 | 9 |  |  |  |  |  |
|  | 6452 | 17.125 | ...... | ...... |  |  |  |  |  |
|  | (14) | 26.078 | ...... | ...... | 46 13 13.3 | − 9 21.2 | +1.8 | ........ | 46 3 53.9 |
|  | 6493 | 4.140 | ...... | ...... |  |  |  |  |  |
|  | (15) | 4.100 | 17 | 18 |  |  |  |  |  |
|  | 6530 | 25.295 | 20 | 14 |  |  |  |  |  |
|  | 6551 | 14.590 | 20 | 15 | 46 4 37.4 | 0 46.8 | +3.4 | ........ | 3 54.0 |
|  | 6581 | 13.435 | 19.5 | 15 |  |  |  |  |  |
|  | 6629 | 19.560 | 21 | 14 | 46 11 19.4 | − 7 28.7 | +3.8 | ........ | 3 54.5 |
|  | 6648 | 8.480 | 19.5 | 15 |  |  |  |  |  |
|  | 6681 | 8.643 | 22 | 13.5 | 45 59 31.6 | + 4 23.7 | +3.4 | ........ | 3 58.7 |
|  | 6698 | 14.155 | 18 | 17 |  |  |  |  |  |
|  | (11) | 17.060 | 21 | 14 | 46 4 39.7 | − 0 47.9 | +3.4 | ........ | 3 55.2 |
|  | 6722 | 15.878 | 18.5 | 16 |  |  |  |  |  |
|  | 6748 | 4.535 | 18.5 | 16.5 | 45 52 41.3 | +11 11.7 | +4.7 | ........ | 3 57.7 |
|  | 6771 | 21.120 | 23 | 12 |  |  |  |  |  |
|  | 6780 | 6.470 | ...... | ...... | 46 13 31.0 | − 9 40.0 | [+3.0] | ........ | 3 54.0 |
|  | 6777 | 20.790 | ...... | ...... |  |  |  |  |  |
|  | 6810 | 10.250 | 15 | 20 | 46 7 58.6 | − 0 4.6 | +1.3 | ........ | 3 55.3 |
|  | 6836 | 16.290 | 22 | 13.5 |  |  |  |  |  |
|  | 6879 | 19.918 | 15.5 | 19.5 | 45 57 9.1 | + 6 45.9 | +1.8 | ........ | 3 56.8 |
|  | 6905 | 9.895 | 22 | 13 |  |  |  |  |  |
|  | 6930 | 10.030 | 20 | 15 | 45 56 13.7 | + 7 40.7 | +2.7 | ........ | 3 57.1 |
|  | 6957 | 21.405 | 19 | 16.5 |  |  |  |  |  |
|  | 6990 | 15.820 | 14 | 22 | 45 58 22.4 | + 5 31.1 | +2.7 | ........ | 3 56.2 |
|  | 7035 | 12.520 | ...... | ...... |  |  |  |  |  |
|  | 7055 | 12.770 | 25.5 | 10 |  |  |  |  |  |
|  | 7098 | 24.440 | 15 | 21 | 46 15 2.0 | (?)* | +3.6 | ........ | (?) |
|  | 7152 | 7.070 | 26 | 10 |  |  |  |  |  |
|  | 7166 | 2.640 | 19 | 16.5 | 45 48 50.2 | +15 1.5 | +3.1 | ........ | 46 3 54.8 |
|  | 7213 | 24.900 | 20 | 14 |  |  |  |  |  |

fear some complicated error; perhaps 7.930 should be the reading for 7152; which gives 3′ 56″.9.

### *Discussion of latitude, Walla Walla.*

| Combination. | Number observations. | Number stars. | Latitude. | | | Correction to micrometer. | Combination. | Number observations. | Number stars. | Latitude. | | | Correction to micrometer. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | ° | ′ | ″ | | | | | ° | ′ | ″ | |
| 1........ | 1 | 2 | 46 | 3 | 52.6 | − 0.43 | 17........ | 3 | 2 | 46 | 3 | 54.30 | + 0.87 |
| 2........ | 2 | 2 | | | 55.20 | + 0.97 | 18........ | 1 | 2 | | | 57.6 | + 0.85 |
| 3........ | 2 | 2 | | | 52.95 | + 1.27 | 19........ | 5 | 2 | | | 55.36 | + 0.36 |
| 4........ | 1 | 2 | | | 54.9 | + 1.81 | 20........ | 5 | 2 | | | 58.12 | − 0.61 |
| 5........ | 3 | 4 | | | 54.60 | + 0.06 | 21........ | 5 | 2 | | | 57.30 | − 0.69 |
| 6........ | 3 | 2 | | | 53.77 | + 1.19 | 22........ | 5 | 3 | | | 57.78 | − 0.50 |
| 7........ | 2 | 2 | | | 55.25 | + 0.06 | 23........ | 6 | 2 | | | 55.38 | + 1.00 |
| 8........ | 1 | 2 | | [4 | 1.2?] | − 0.11 | 24........ | 4 | 2 | | | 56.88 | − 1.36 |
| 9........ | 2 | 3 | | 3 | 58.50 | − 0.95 | 25........ | 4 | 2 | | | 53.40 | + 1.23 |
| 10........ | 5 | 5 | | | 55.54 | + 0.36 | 26........ | 4 | 2 | | | 56.62 | − 0.67 |
| 11........ | 2 | 4 | | | 53.00 | + 1.06 | 27........ | 4 | 3 | | | 55.32 | − 0.01 |
| 12........ | 4 | 2 | | | 55.20 | + 0.06 | 28........ | 4 | 3 | | | 56.02 | − 0.21 |
| 13*........ | 4 | 2 | | | 55.32 | + 0.67 | 29........ | 4 | 2 | | | 54.82 | + 0.72 |
| 14........ | 4 | 2 | | | 57.45 | − 0.40 | 30........ | 4 | 4 | | | 56.42 | − 0.84 |
| 15........ | 3 | 2 | | | 56.20 | + 0.06 | 31........ | 3 | 2 | 46 | 3 | 58.40 | + 1.21 |
| 16........ | 5 | 2 | | | 55.72 | − 1.02 | | | | | | | |

*Observation of August 13, excluded.

#### FINAL LATITUDE.

46° 3′ 55″.89 ± 0″.16.

#### TABLE OF WEIGHTS.

| | | |
|---|---|---|
| 2 stars, 1 obs.......... | 0.5 | |
| 2 obs.......... | 0.75 | |
| 3–6 obs........ | 1.00 | |
| 3 stars................. | 1.33 | for 3 to 6 observations { Diminished in above proportion for less. |
| 4 stars................. | 2. | |
| 5 stars................. | 2.4 | |

## ASTRONOMICAL STATION AT THE DALLES, OREGON, 1878.

### GEOGRAPHICAL POSITION.

Latitude, 45° 36′ 17″.78.
Longitude, 121° 12′ 20″.47.
Barometric altitude of observatory above sea-level (monument) 179.8 feet.

The point selected for the determination in The Dalles was on the bluff of the lava bed, under the shadow of which are the Steam Navigation Company's offices and workshops.

The pier was of cemented brick, and in a position not likely to be disturbed, unless by some irrational wantonness. From here one can not only overlook the whole city, but have an unobstructed view of the lofty and snow-covered cone of Mount Hood; and, but for a mountain ridge just across the Columbia River, Mount Adams would also be visible. From the pier the northwest corner section 3, township 1 north, range 13 east bears N. 33° W., distant 47¼ feet; and to the south side of Main street, if it were prolonged, the distance is 81¼ feet. (See plate herewith.) The meridian was marked on the north near the bluff facing the Columbia River, by an iron pin driven into the ground and then covered by a conical pile of rocks 6 feet wide and 4 feet high; southward, on a large natural mound (which was once a part of the military reservation of old Fort Dalles), it was indicated in the same way.

### DALLES CITY AND SURROUNDINGS.

The Dalles, or Dalles City, in the language of its incorporation, is situated at the mouth of Mill Creek, a very considerable distance below the main part of the rapids of the Columbia River, from which it takes its name. It is a strangely selected spot for a city, for what is not lava-bed is for the most part sand. Once there was a level and fertile valley between the city and the foot of the rapids, but this is now almost entirely covered with sand dunes. The wind that pours up the cañon, that sets in at the mouth of Mill Creek, like water through a funnel, is apparently the cause of all this sand in and about the city. Despite the forbidding character of the location, Dalles City is a picturesque, go-ahead town, having many fine stores and pleasant residences with their charming fruit gardens.

### METEOROLOGICAL CONDITIONS.

It took no less than four weeks to complete this station, from August 29 to September 25. Arrangements for observations were ready on the 30th. September 1, however, a violent wind carried everything in the shape of tent and other equipments to the ground, making it necessary to put up a substantial frame-work.

Observations were made, or it was possible to make them, September 2, 3, 4, 5, 6, 7, 8, and 9, although there was much embarrassment from the wind.

From September 10 to 19, inclusive, the atmosphere was so full of smoke driven from the burning Cascade Mountains that no observations could be made. A few of the very largest stars could sometimes be faintly seen. During this time the sun was stripped of its power and stood in the heavens as a great blood-red rayless orb; the moon had the same general appearance by night; the wind blowing all the while eastward and sometimes violently. From the 19th to the 25th the weather was for the most part favorable, if the wind be excepted.

### TELEGRAPHIC COMMUNICATION.

The Western Union Office and that of the Oregon Steam Navigation Company not being connected in Portland, an effort was made at first to get Ogden by way of Walla-Walla, Boise City, and Winnemucca. The most patient perseverance for many nights brought success but once in this direction, September 5.

The offices in Portland having been connected, the rest of the signal exchanges were made by Portland and San Francisco, that circuitous but expeditious route.

Length of circuit via Walla-Walla, about 1,144 miles; via Portland about 1,500 miles.

### METHOD OF OBSERVATION.

Mode of observation the same as at Walla-Walla; that is, eye and ear. The chronometer did not have to be taken so far, but the climbing up and down the bluff was anything but a safe or pleasant operation.

### INSTRUMENTS.

Instruments the same as at Walla-Walla. No. 16 is an old instrument and has been put to much service in many places, but the roughest usage it ever had, it received probably from the wind and sand of Dalles City, Oregon.

*Tabulation of stars used for determination of time at Ogden, Utah, and The Dalles, Oreg.*

| Name of star. | Ogden. | | | | | The Dalles, Oreg. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sept. 5. | Sept. 17. | Sept. 20. | Sept. 21. | Sept. 22. | Sept. 5. | Sept. 17. | Sept. 20. | Sept. 21 | Sept. 22. |
| ο Herculis | × | | | | | | | | | |
| A Herculis | × | | | | | | | | | |
| 204 Heis Herculis | × | | | | | | | | | |
| κ Lyræ | | | × | | × | | | | | |
| 109 Herculis | | | × | | × | | | | | × |
| χ Draconis | × | | | × | × | | | × | | × |
| 9 Heis Lyræ | × | | × | | × | | | | | |
| 11 Heis Lyræ | × | | | | | | | | | |
| 3 Heis Scuti | | | | | | | | × | | |
| α Lyræ | | | × | × | × | | | × | | × |
| Groom. 2655 | × | | | | | | | | | |
| 110 Herculis | | | | | | | | × | | × |
| β Lyræ | | | | × | | | | × | | × |
| ο Sagittarii | | | | | | | | × | | × |
| δ² Lyræ | | | | × | | | | | | |
| γ Lyræ | × | | × | × | × | | | × | | × |
| 16 Lyræ | × | | | | | | | | | |
| ζ Aquilæ | | | × | | × | | | × | | × |
| ι Lyræ | | | × | | × | | | | | |
| 25 Hev. Camelopard., S. P | × | | | | | | | | | |
| 19 Lyræ | | | × | | × | | | | | |
| δ Draconis | | | × | | × | | | × | | × |
| θ Lyræ | × | | | | | | | | | |
| τ Draconis | × | | × | × | × | | | | | |
| δ Aquilæ | | | | | | | × | × | × | × |
| 4 Cygni | × | | | × | | | | | | |
| β Cygni | × | | | × | | | × | × | × | × |
| κ Aquilæ | | | | | | | × | × | × | × |
| 9 Cygni | | | | × | | | | | | |

*Tabulation of stars used for determination of time at Ogden, &c.*—Continued.

| Name of star. | Ogden. |  |  |  |  | The Dalles, Oreg. |  |  |  |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  | Sept. 5. | Sept. 17. | Sept. 20. | Sept. 21. | Sept. 22 | Sept. 5. | Sept. 17 | Sept. 20. | Sept. 21. | Sept. 22. |
| φ Cygni |  |  |  | × |  |  |  |  |  |  |
| 28 Heis Cygni |  |  |  | × |  |  |  |  |  |  |
| γ Aquilæ |  |  |  |  |  |  | × | × | × | × |
| α Aquilæ |  |  |  |  |  |  | × |  |  |  |
| ε Draconis |  |  |  | × |  |  | × | × | × | × |
| γ Sagittæ |  |  |  |  |  |  | × |  | × |  |
| τ Aquilæ |  |  |  |  |  |  |  |  | × |  |
| θ Aquilæ |  |  |  |  |  | × |  |  | × |  |
| α² Capricorni |  |  |  |  |  | × |  |  |  |  |
| κ Cephei |  |  |  |  |  |  | × |  |  |  |
| γ Cygni |  |  |  |  |  | × |  |  |  |  |
| ε Delphini |  |  |  |  |  | × | × |  |  |  |
| Groom. 3241 |  |  |  |  |  | × |  |  |  |  |
| 73 Draconis | × |  |  |  |  |  |  |  |  |  |
| α Cygni | × | × |  |  |  | × | × |  |  |  |
| ε Cygni | × | × |  |  |  | × |  |  |  |  |
| Pi. XX, 358 | × |  |  |  |  |  |  |  |  |  |
| 32 Vulpeculæ | × |  |  |  |  |  |  |  |  |  |
| Br. 2749 | × |  |  |  |  | × |  |  |  |  |
| 61 Cygni, pr |  |  |  |  |  | × |  |  |  |  |
| Pi. XXI, 1 | × |  |  |  |  |  |  |  |  |  |
| 77 Draconis | × |  |  |  |  |  |  |  |  |  |
| ζ Cygni |  |  |  |  |  | × |  | × | × |  |
| α Cephei |  | × |  |  |  | × | × | × | × |  |
| 1 Pegasi | × |  |  |  |  |  |  |  |  |  |
| Pi. XXI, 120 | × |  |  |  |  |  |  |  |  |  |
| 70 Cygni | × |  |  |  |  |  |  |  |  |  |
| β Aquarii |  |  |  |  |  | × | × | × | × |  |
| Groom. 3511 | × |  |  |  |  |  |  |  |  |  |
| ξ Aquarii |  |  |  |  |  |  |  | × | × |  |
| ε Pegasi |  | × |  |  |  |  | × |  |  |  |
| 11 Cephei |  |  | × | × |  |  |  | × | × |  |
| μ Capricorni |  |  |  |  |  |  |  | × |  |  |
| 16 Pegasi |  |  | × | × |  |  |  |  |  |  |
| 17 Pegasi |  |  | × | × |  |  |  |  |  |  |
| 79 Draconis |  |  |  |  |  |  |  |  | × |  |
| 20 Pegasi |  |  | × | × |  |  |  |  |  |  |
| α Aquarii |  |  |  |  |  |  |  | × |  |  |
| 27 Pegasi |  |  |  | × | × |  |  |  |  |  |
| π Pegasi |  |  | × |  |  |  |  |  |  |  |
| 24 Cephei |  |  | × | × | × |  |  |  |  |  |
| 1 Lacertæ |  |  |  |  | × |  |  |  |  |  |
| 31 Pegasi |  |  |  |  | × |  |  |  |  |  |
| 38 Pegasi |  |  | × | × |  |  |  |  |  |  |
| Groom. 3804 |  |  | × | × | × |  |  |  |  |  |
| Pi. XXII. 158 |  |  |  |  | × |  |  |  |  |  |
| 31 Cephei |  |  | × | × | × |  |  |  |  |  |
| η Pegasi |  |  | × | × | × |  |  |  |  |  |
| λ Pegasi |  |  | × | × | × |  |  |  |  |  |

*The Dalles, September 5, 1878; after signals.*

| Name of star. | Clamp. | T. | | | B*b*. | A *a*. | C *c*. | T′. | | | A. R. | | | Δ T. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *s.* |
| θ Aquilæ | E. | 20 | 5 | 8.94 | + 0.02 | + 5.08 | + 1.26 | 20 | 5 | 15.30 | 20 | 5 | 4.46 | − 10.84 |
| α Capriconi | E. | | 11 | 24.84 | + 0.01 | + 6.10 | + 1.20 | | 11 | 32.24 | | 11 | 21.29 | 10.95 |
| γ Cygni | E. | | 18 | 2.22 | + 0.03 | + 0.91 | + 1.64 | | 17 | 4.80 | | 18 | 54.18 | 10.62 |
| ε Delphini | E. | | 27 | 32.70 | + 0.02 | + 4.04 | + 1.28 | | 27 | 38.04 | | 27 | 26.77 | 11.27 |
| Gr. 3241 | E. | | 30 | 51.08 | + 0.07 | −10.14 | + 4.10 | | 30 | 45.11 | | 30 | 33.80 | 11.31 |
| α Cygni | E. | | 37 | 28.40 | + 0.03 | + 0.13 | + 1.77 | | 37 | 30.33 | | 37 | 19.58 | 10.75 |
| ε Cygni | E. | | 41 | 27.52 | + 0.03 | + 1.75 | + 1.51 | | 41 | 30.81 | | 41 | 19.92 | 10.89 |
| Bradley 2749 | W. | 20 | 53 | 48.24 | − 0.33 | −22.94 | − 7.31 | 20 | 53 | 17.66 | 20 | 53 | 6.46 | 11.20 |
| 61 Cygni pr | W. | 21 | 1 | 40.90 | − 0.09 | + 1.15 | − 1.60 | 21 | 1 | 40.36 | 21 | 1 | 29.36 | 11.00 |
| ξ Cygni | W. | | 7 | 58.36 | − 0.08 | + 2.19 | − 1.44 | | 7 | 59.03 | | 7 | 48.21 | 10.82 |
| α Cephei | W. | | 16 | 1.02 | − 0.14 | − 4.22 | − 2.68 | | 15 | 53.98 | | 15 | 43.24 | 10.74 |
| β Aquarii | W. | 21 | 25 | 19.18 | − 0.04 | + 5.50 | − 1.26 | 21 | 25 | 23.38 | 21 | 25 | 12.36 | − 11.02 |

NORMAL EQUATIONS.

$a_0 = +\,7^s.2 \qquad c_0 = +\,1^s.2 \qquad \Delta\,T_0 = -\,11^s.00 \qquad \text{for } 21^h.0$

$$\begin{aligned}
& \quad\ \ {}^{s.} \\
0 &= -\,0.286 + 9.29\,d\,\Delta\,T + 2.67\,da + 2.16\,dc \\
0 &= +\,0.619 + 2.67\,d\,\Delta\,T + 4.41\,da + 3.10\,dc \\
0 &- -\,0.606 + 2.16\,d\,\Delta\,T + 3.10\,da + 20.20\,dc
\end{aligned}$$

$$\begin{aligned}
d\,\Delta\,T &= +\,0.084^{s.} & \Delta\,T &= -\,10.916^{s.}\ (\text{wt.} = 7.67) \\
da &= -\,0.231 & a &= +\,6.969\ (\text{wt.} = 3.33) \\
dc &= +\,0.057 & c &= +\,1.257\ (\text{wt.} = 18.01)
\end{aligned}$$

*The Dalles, September 17, 1878.*

| Name of star. | Clamp. | T. | | | B *b*. | A *a*. | C *c*. | T′. | | | A. R. | | | ΔT. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *s.* |
| δ Aquilæ | W. | 19 | 19 | 28.06 | + 0.15 | + 2.30 | − 0.19 | 19 | 19 | 30.32 | 19 | 19 | 24.28 | − 6.04 |
| β Cygni | W. | | 25 | 55.52 | + 0.22 | + 1.17 | − 0.21 | | 25 | 56.70 | | 25 | 50.99 | 5.71 |
| κ Aquilæ | W. | | 30 | 26.92 | + 0.12 | + 2.72 | − 0.19 | | 30 | 29.57 | | 30 | 23.41 | 6.16 |
| γ Aquilæ | W. | | 40 | 34.80 | + 0.17 | + 1.98 | − 0.19 | | 40 | 36.76 | | 40 | 30.96 | 5.80 |
| α Aquilæ | W. | | 44 | 57.10 | + 0.16 | + 2.06 | − 0.19 | | 44 | 59.13 | | 44 | 53.31 | 5.82 |
| ε Draconis | W. | | 48 | 45.68 | + 0.55 | − 4.07 | − 0.54 | | 48 | 41.62 | | 48 | 35.95 | 5.67 |
| γ Sagittæ | W. | 19 | 53 | 27.32 | + 0.20 | + 1.59 | − 0.20 | 19 | 53 | 28.91 | 19 | 53 | 23.15 | 5.76 |
| κ Cephei | E. | 20 | 13 | 11.24 | + 0.98 | − 8.12 | + 0.85 | 20 | 13 | 4.95 | 20 | 12 | 58.60 | 6.35 |
| ε Delphini | E. | | 27 | 30.18 | + 0.21 | + 1.96 | + 0.19 | | 27 | 32.54 | | 27 | 26.65 | 5.89 |
| α Cygni | E. | 20 | 37 | 24.44 | + 0.36 | + 0.06 | + 0.26 | 20 | 37 | 25.12 | 20 | 37 | 19.37 | 5.75 |
| α Cephei | E. | 21 | 15 | 49.84 | + 0.52 | − 2.05 | + 0.40 | 21 | 15 | 48.71 | 21 | 15 | 42.95 | 5.76 |
| β Aquarii | E. | | 25 | 15.11 | + 0.16 | + 2.67 | + 0.19 | | 25 | 18.13 | | 25 | 12.31 | 5.82 |
| ε Pegasi | E. | 21 | 38 | 18.86 | + 0.21 | + 2.03 | + 0.19 | 21 | 38 | 21.29 | 21 | 38 | 15.55 | − 5.74 |

NORMAL EQUATIONS.

$a_0 = +3^s.5 \qquad c_0 = +0^s.2 \qquad \Delta T_0 = -5^s.8 \qquad \text{for } 20^h.0$

$$
\begin{aligned}
&\overset{s.}{\phantom{0}}\\
0 &= +1.038 + 10.36\, d\Delta T + 4.35\, da - 0.38\, dc \\
0 &= +0.739 + 4.35\, d\Delta T + 4.77\, da - 3.72\, dc \\
0 &= -0.208 - 0.88\, d\Delta T - 3.72\, da + 18.32\, dc
\end{aligned}
$$

$$
\begin{aligned}
d\Delta T &= -\overset{s.}{0.051} & \Delta T &= -\overset{s.}{5.851}\ (\text{wt.} = 5.82) \\
da &= -0.120 & a &= +3.380\ (\text{wt.} = 2.25) \\
dc &= -0.014 & c &= +0.186\ (\text{wt.} = 14.00)
\end{aligned}
$$

*The Dalles, September 20, 1878; before signals.*

| Name of star. | Clamp. | T. | | | B *b*. | A *a*. | C *c*. | T′. | | | A. R. | | | Δ T. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *s.* |
| χ Draconis | E. | 18 | 23 | 26.38 | − 0.16 | − 5.47 | + 0.77 | 18 | 23 | 21.52 | 18 | 23 | 14.67 | − 6.85 |
| 3 H. Scuti | E. | | 28 | 41.16 | − 0.03 | + 2.92 | + 0.23 | | 28 | 44.28 | | 28 | 37.50 | − 6.78 |
| α Lyræ | E. | | 32 | 56.60 | − 0.07 | + 0.55 | + 0.29 | | 32 | 57.37 | | 32 | 50.71 | − 6.66 |
| 110 Herculis | E. | | 40 | 32.50 | − 0.05 | + 1.62 | + 0.24 | | 40 | 34.31 | | 40 | 27.47 | − 6.84 |
| β Lyræ | E. | | 45 | 42.84 | − 0.06 | + 0.92 | + 0.27 | | 45 | 43.97 | | 45 | 37.02 | − 6.95 |
| σ Sagittarii | E. | | 47 | 48.90 | − 0.02 | + 3.80 | + 0.26 | | 47 | 52.94 | | 47 | 46.03 | − 6.91 |
| γ Lyræ | W. | | 54 | 31.60 | − 0.20 | + 0.96 | − 0.27 | | 54 | 32.09 | | 54 | 25.33 | − 6.76 |
| ζ Aquilæ | W. | 18 | 59 | 56.50 | − 0.15 | + 1.94 | − 0.24 | 18 | 59 | 58.05 | 18 | 59 | 51.21 | − 6.84 |
| δ Draconis | W. | 19 | 12 | 43.42 | − 0.42 | − 3.47 | − 0.60 | 19 | 12 | 38.93 | 19 | 12 | 32.20 | − 6.73 |
| δ Aquilæ | W. | | 19 | 28.90 | − 0.13 | + 2.43 | − 0.23 | | 19 | 30.97 | | 19 | 24.23 | − 6.74 |
| β Cygni | W. | | 25 | 56.92 | − 0.19 | + 1.24 | − 0.26 | | 25 | 57.71 | | 25 | 50.94 | − 6.77 |
| κ Aquilæ | W. | | 30 | 27.66 | − 0.11 | + 2.87 | − 0.23 | | 30 | 30.19 | | 30 | 23.36 | − 6.83 |
| γ Aquilæ | W. | | 40 | 36.14 | − 0.14 | + 2.10 | − 0.23 | | 40 | 37.87 | | 40 | 30.91 | − 6.96 |
| ε Draconis | W. | 19 | 48 | 48.16 | − 0.46 | − 4.30 | − 0.67 | 19 | 48 | 42.73 | 19 | 48 | 35.77 | − 6.96 |

NORMAL EQUATIONS.

$a_0 = +3^s.5 \qquad c_0 = +0^s.2 \qquad \Delta T_0 = -6^s.80 \qquad \text{for } 19^h.0$

$$0 = +\overset{s.}{0.039} + 11.14\, d\Delta T + 4.11\, da - 1.16\, dc$$
$$0 = -0.278 + 4.11\, d\Delta T + 5.21\, da + 0.28\, dc$$
$$0 = -0.670 - 1.16\, d\Delta T + 0.28\, da + 21.42\, dc$$

$$d\Delta T = -\overset{s.}{0.028} \qquad \Delta T = -\overset{s.}{6.828} \text{ (wt. = 7.81)}$$
$$da = +0.074 \qquad a = +8.574 \text{ (wt. = 3.67)}$$
$$dc = +0.029 \qquad c = +0.229 \text{ (wt. = 21.16)}$$

### *The Dalles, September 20, 1878; after signals.*

| Name of star. | Clamp. | T. | B*b*. | A*a*. | C*c*. | T′. | A. R. | ΔT. |
|---|---|---|---|---|---|---|---|---|
| | | *h.* *m.* *s.* | *s.* | *s.* | *s.* | *h.* *m.* *s.* | *h.* *m.* *s.* | *s.* |
| ζ Cygni | W. | 21 7 54.14 | − 0.28 | + 1.18 | − 0.24 | 21 7 54.80 | 21 7 48.07 | − 6.78 |
| α Cephei | W. | 15 52.90 | − 0.51 | − 2.26 | − 0.45 | 15 49.68 | 15 42.87 | 6.81 |
| β Aquarii | W. | 25 16.66 | − 0.16 | + 2.95 | − 0.21 | 25 19.24 | 25 12.29 | 6.95 |
| ξ Aquarii | W. | 31 23.76 | − 0.15 | + 3.06 | − 0.21 | 31 26.46 | 31 19.63 | 6.83 |
| 11 Cephei | E. | 40 22.20 | − 0.39 | − 4.82 | + 0.63 | 40 17.62 | 40 10.76 | 6.86 |
| μ Capricorni | E. | 46 46.22 | − 0.07 | + 3.33 | + 0.22 | 46 49.70 | 46 43.00 | 6.70 |
| α Aquarii | E. | 21 59 39.24 | − 0.10 | + 2.71 | + 0.21 | 21 59 42.06 | 21 59 35.16 | − 6.90 |

NORMAL EQUATIONS.

$a_0 = +3^s.5 \qquad c_0 = +0^s.2 \qquad \Delta T_0 = -6^s.8 \qquad \text{for } 21^h.5$

$$0 = -0^s.500 + 5.81\,d\Delta T + 2.72\,da - 1.18\,dc$$
$$0 = -0.749 + 2.72\,d\Delta T + 3.46\,da - 0.97\,dc$$
$$0 = +0.105 - 1.18\,d\Delta T - 0.97\,da + 10.99\,dc$$

$$d\wedge T = -0^s.023 \qquad \Delta T = -6^s.823 \text{ (wt.} = 3.65)$$
$$da = +0.237 \qquad a = +3.737 \text{ (wt.} = 2.17)$$
$$dc = +0.009 \qquad c = +0.209 \text{ (wt.} = 10.67)$$

*The Dalles, September 21, 1878.*

| Name of star. | Clamp. | T. | | | B*b*. | A*a*. | C*c*. | T′. | | | A.R. | | | ΔT. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *s.* |
| δ Aquilæ | E. | 19 | 19 | 32.74 | − 0.02 | − 2.09 | + 0.24 | 19 | 19 | 30.87 | 19 | 19 | 24.22 | − 6.65 |
| β Cygni | E. | | 25 | 58.14 | − 0.03 | − 1.07 | + 0.27 | | 25 | 57.31 | | 25 | 50.92 | − 6.39 |
| κ Aquilæ | E. | | 30 | 32.18 | − 0.02 | − 2.48 | + 0.24 | | 30 | 29.92 | | 30 | 23.42 | − 6.50 |
| γ Aquilæ | E. | | 40 | 39.24 | − 0.02 | − 1.81 | + 0.24 | | 40 | 37.65 | | 40 | 30.90 | − 6.75 |
| ε Draconis | E. | | 48 | 38.80 | − 0.07 | + 3.70 | + 0.69 | | 48 | 43.12 | | 48 | 35.71 | − 7.41 |
| γ Sagittæ | W. | | 53 | 31.54 | + 0.03 | − 1.45 | − 0.25 | | 53 | 29.87 | | 53 | 23.09 | − 6.78 |
| τ Aquilæ | W. | 19 | 58 | 23.22 | + 0.02 | − 1.94 | − 0.24 | 19 | 58 | 21.06 | 19 | 58 | 14.33 | − 6.73 |
| θ Aquilæ | W. | 20 | 5 | 13.66 | + 0.02 | − 2.24 | − 0.24 | 20 | 5 | 11.20 | 20 | 5 | 4.27 | − 6.93 |
| ζ Cygni | W. | 21 | 7 | 55.86 | + 0.01 | − 0.97 | − 0.27 | 21 | 7 | 54.63 | 21 | 7 | 48.05 | − 6.58 |
| α Cephei | W. | | 15 | 47.88 | + 0.02 | + 1.86 | − 0.50 | | 15 | 49.26 | | 15 | 42.84 | − 6.42 |
| β Aquarii | W. | | 25 | 21.46 | 0.00 | − 2.43 | − 0.24 | | 25 | 18.79 | | 25 | 12.28 | − 6.51 |
| ξ Aquarii | W. | | 31 | 28.92 | 0.00 | − 2.52 | − 0.24 | | 31 | 26.16 | | 31 | 19.62 | − 6.54 |
| 11 Cephei | E. | | 40 | 11.96 | + 0.35 | + 3.97 | + 0.72 | | 40 | 17.00 | | 40 | 10.72 | − 6.28 |
| 79 Draconis | E. | 21 | 51 | 24.28 | + 0.38 | + 4.90 | + 0.81 | 21 | 51 | 30.37 | 21 | 51 | 24.00 | − 6.37 |

NORMAL EQUATIONS.

$a_0 = -3^s.0 \qquad c_0 = +0^s.2 \qquad \Delta T_0 = -6^s.7 \qquad \text{for } 20^h.5$

$$\begin{aligned}
&\quad\ \ s.\\
0 &= -0.309 + 11.26\, d\,\Delta T + 4.61\, da - 0.50\, dc\\
0 &= +0.321 + 4.61\, d\,\Delta T + 5.81\, da - 4.21\, dc\\
0 &= -1.059 - 0.50\, d\,\Delta T - 4.21\, da + 21.44\, dc
\end{aligned}$$

$$\begin{aligned}
&\qquad\ \ s. && \qquad\quad s.\\
d\,\Delta T &= +0.061 & \Delta T &= -6.639\ (\text{wt.} = 7.17)\\
da &= -0.078 & a &= -3.078\ (\text{wt.} = 3.17)\\
dc &= +0.036 & c &= +0.276\ (\text{wt.} = 17.33)
\end{aligned}$$

*The Dalles, September 22, 1878.*

| Name of star. | Clamp. | T. |  |  | B*b*. | A*a*. | C*c*. | T′. |  |  | A. R. |  |  | ΔT. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *s.* |
| 109 Herculis | E. | 18 | 18 | 39.22 | + 0.06 | − 0.82 | + 0.37 | 18 | 18 | 38.83 | 18 | 18 | 32.57 | − 6.26 |
| χ Draconis | E. |  | 25 | 16.76 | + 0.18 | + 2.86 | + 1.17 |  | 25 | 20.97 |  | 23 | 14.50 | 6.47 |
| α Lyræ | E. |  | 33 | 56.56 | + 0.08 | − 0.29 | + 0.44 |  | 33 | 56.79 |  | 32 | 50.65 | 6.14 |
| 110 Herculis | E. |  | 40 | 34,26 | + 0.06 | − 0.85 | + 0.37 |  | 40 | 33.84 |  | 40 | 27.43 | 6.41 |
| β Lyræ | E. |  | 45 | 43.24 | + 0.07 | − 0.48 | + 0.42 |  | 45 | 43.25 |  | 45 | 36.86 | 6.39 |
| σ Sagittarii | E. |  | 47 | 53.87 | + 0.02 | − 1.99 | + 0.39 |  | 47 | 52.29 |  | 47 | 46.00 | 6.29 |
| γ Lyræ | E. |  | 54 | 31.46 | + 0.07 | − 0.50 | + 0.41 |  | 54 | 31.44 |  | 54 | 25.28 | 6.16 |
| ζ Aquilæ | W. | 18 | 59 | 58.70 | + 0.08 | − 1.02 | − 0.36 | 18 | 59 | 57.40 | 18 | 59 | 51.18 | 6.22 |
| δ Draconi | W. | 19 | 12 | 37.00 | + 0.23 | + 1.82 | − 0.90 | 19 | 12 | 38.15 | 19 | 12 | 32.09 | 6.06 |
| δ Aquilæ | W. |  | 19 | 32.08 | + 0.07 | − 1.27 | − 0.35 |  | 19 | 30.53 |  | 19 | 24.20 | 6.33 |
| β Cygni | W. |  | 25 | 58.14 | + 0.10 | − 0.65 | − 0.39 |  | 25 | 57.20 |  | 25 | 50.90 | 6.30 |
| κ Aquilæ | W. |  | 30 | 31.42 | + 0.06 | − 1.50 | − 0.35 |  | 30 | 29.63 |  | 30 | 23.33 | 6.30 |
| γ Aquilæ | W. |  | 40 | 38.70 | + 0.08 | − 1.10 | − 0.35 |  | 40 | 37.33 |  | 40 | 30.88 | 6.45 |
| ε Draconis | W. | 19 | 48 | 40.64 | + 0.25 | + 2.25 | − 1.01 | 19 | 48 | 42.13 | 19 | 48 | 35.65 | − 6.48 |

NORMAL EQUATIONS.

$a_0 = -1^s.8 \qquad c_0 = +0^s.2 \qquad \Delta T_0 = -6^s.3 \qquad \text{for } 19^h.0$

$$\begin{aligned} &\quad\ \ s. \\ 0 &= +0.295 + 11.40\, d\,\Delta T + 3.91\, da - 0.07\, dc \\ 0 &= +0.287 + 3.91\, d\,\Delta T + 4.84\, da + 0.40\, dc \\ 0 &= -3.192 - 0.07\, d\,\Delta T + 0.40\, da + 21.84\, dc \end{aligned}$$

$$\begin{aligned} d\,\Delta T &= -0.001 \qquad \Delta T = -6.301\ (\text{wt.} = 8.24) \\ da &= -0.071 \qquad\quad a = -1.871\ (\text{wt.} = 3.49) \\ dc &= +0.147 \qquad\quad c = +0.347\ (\text{wt.} = 21.79) \end{aligned}$$

*Ogden, September 5, 1878; before signals.*

| Name of star. | Clamp. | T. | | | B*b*. | *a*. | C*c*. | T'. | | | A. R. | | | ΔT. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| *o* Herculis | E. | 18 | 5 | 40.05 | + 0.01 | + 0.08 | + 0.18 | 18 | 5 | 40.32 | 18 | 2 | 49.67 | − 2 | 50.65 |
| A Herculis | E. | 18 | 10 | 11.72 | + 0.01 | + 0.07 | + 0.19 | | 10 | 11.99 | 18 | 7 | 21.38 | 2 | 50.61 |
| 204 Heis Herculis | E. | 18 | 15 | 39.42 | + 0.01 | + 0.14 | + 0.17 | | 15 | 39.74 | 18 | 12 | 49.05 | 2 | 50.69 |
| χ Draconis | E. | 18 | 26 | 6.44 | + 0.02 | − 0.60 | + 0.53 | | 26 | 6.39 | 18 | 23 | 15.65 | 2 | 50.74 |
| 9 Heis Lyræ | E. | 18 | 31 | 8.36 | + 0.01 | + 0.07 | + 0.18 | | 31 | 8.62 | 18 | 28 | 12.77 | 2 | 50.85 |
| 11 Heis Lyræ | E. | 18 | 35 | 2.03 | + 0.01 | + 0.06 | + 0.19 | | 35 | 2.29 | 18 | 32 | 11.47 | 2 | 50.82 |
| Gr. 2655 | E. | 18 | 38 | 29.16 | + 0.03 | − 0.94 | + 0.73 | | 38 | 28.98 | 18 | 35 | 37.58 | 2 | 51.40 |
| γ Lyræ | W. | 18 | 57 | 16.50 | − 0.05 | + 0.06 | − 0.19 | 18 | 57 | 16.32 | 18 | 54 | 25.68 | 2 | 50.64 |
| 16 Lyræ | W. | 19 | 0 | 53.16 | − 0.06 | − 0.05 | − 0.23 | 19 | 0 | 52.82 | 18 | 58 | 1.66 | 2 | 51.16 |
| 25 H. Camelop. S P | W. | 19 | 8 | 13.99 | + 0.18 | + 2.22 | + 1.23 | | 8 | 17.62 | 7 | 5 | 25.86 | 2 | 51.76 |
| θ Lyræ | W. | 19 | 15 | 1.74 | − 0.05 | + 0.03 | − 0.20 | | 15 | 1.52 | 19 | 12 | 10.79 | 2 | 50.73 |
| τ Draconis | W. | 19 | 20 | 46.55 | − 0.12 | − 0.62 | − 0.54 | | 20 | 45.27 | 19 | 17 | 54.40 | 2 | 50.87 |
| 4 Cygni | W. | 19 | 24 | 39.57 | − 0.05 | + 0.04 | − 0.20 | | 24 | 39.36 | 19 | 21 | 48.37 | 2 | 50.99 |
| β Cygni | W. | 19 | 28 | 42.22 | − 0.05 | + 0.09 | − 0.18 | 19 | 28 | 42.08 | 19 | 25 | 51.20 | − 2 | 50.88 |

NORMAL EQUATIONS.

$a_0 = +0^s.40 \qquad c_0 = +0^s.15 \qquad \Delta T_0 = -2^m.50^s.83$ for $19^h.0$

$$\begin{aligned}
& \quad\ \ {}^{s.} \\
0 &= -0.169 + 9.907\, d\Delta T + 0.547\, da + 1.169\, dc \\
0 &= +0.341 + 0.547\, d\Delta T + 6.426\, da + 2.045\, dc \\
0 &= -0.121 + 1.169\, d\Delta T + 2.045\, da + 27.698\, dc
\end{aligned}$$

$$\begin{aligned}
& \qquad {}^{s.} & & \quad {}^{m.}\ \ {}^{s.} \\
d\Delta T &= +0.019 & \Delta T &= -2\ \ 50.811\ (\text{wt.} = 9.82) \\
da &= -0.057 & a &= +\ \ 0.343\ (\text{wt.} = 6.25) \\
dc &= +0.008 & c &= +\ \ 0.158\ (\text{wt.} = 26.95)
\end{aligned}$$

*Ogden, September 5, 1878; after signals.*

| Name of star. | Clamp. | T. | B*b*. | A*a*. | C*c*. | T′. | A. R. | ΔT. |
|---|---|---|---|---|---|---|---|---|
| | | *h.* *m.* *s.* | *s.* | *s.* | *s.* | *h.* *m.* *s.* | *h.* *m.* *s.* | *m.* *s.* |
| 73 Draconis | W. | 20 36 0.94 | − 0.19 | − 0.91 | − 0.59 | 20 35 59.25 | 20 33 8.09 | − 2 51.16 |
| α Cygni | W. | 20 40 11.40 | − 0.09 | − 0.04 | − 0.21 | 40 11.06 | 20 37 19.52 | 2 51.54 |
| ε Cygni | W. | 20 44 11.25 | − 0.07 | + 0.07 | − 0.18 | 44 11.07 | 20 41 19.90 | 2 51.17 |
| 32 Vulpeculæ | W. | 20 52 16.43 | − 0.07 | + 0.12 | − 0.17 | 52 16.31 | 20 49 25.17 | 2 51.14 |
| Brdl. 2749 | W. | 20 56 0.05 | − 0.28 | − 1.47 | − 0.88 | 20 55 57.42 | 20 53 6.38 | 2 51.04 |
| Pi. XXI, 1 | E. | 21 6 22.77 | + 0.03 | + 0.10 | + 0.17 | 21 6 23.07 | 21 3 31.96 | 2 51.11 |
| 77 Draconis | E. | 21 10 48.94 | + 0.10 | − 1.23 | + 0.71 | 10 48.52 | 21 7 57.21 | 2 51.31 |
| 1 Pegasi | E. | 21 19 21.23 | + 0.03 | + 0.17 | + 0.16 | 19 21.59 | 21 16 30.36 | 2 51.23 |
| Pi. XXI, 120 | E. | 21 22 3.53 | + 0.03 | + 0.13 | + 0.17 | 22 3.86 | 21 19 12.57 | 2 51.29 |
| 70 Cygni | E. | 21 25 17.28 | + 0.03 | + 0.04 | + 0.19 | 25 17.54 | 21 22 26.46 | 2 51.08 |
| Gr. 3511 | E. | 21 31 17.04 | + 0.12 | − 1.59 | + 0.87 | 21 31 16.44 | 21 28 25.00 | − 2 51.44 |

NORMAL EQUATIONS.

$a_0 = +0^s.40 \qquad c_0 = +0^s.15 \qquad \Delta T_0 = -2^m.51^s.23 \quad \text{for } 21^h.0$

$$\begin{array}{l} \quad s. \\ 0 = -0.068 + 7.058\, d\Delta T - 0.550\, da + 0.836\, dc \\ 0 = -0.241 - 0.550\, d\Delta T + 5.883\, da + 0.428\, dc \\ 0 = -0.044 + 0.836\, d\Delta T + 0.428\, da + 24.137\, dc \end{array}$$

$$\begin{array}{rlrl} & \quad s. & & m. \quad s. \\ d\Delta T = & +0.013 & \Delta T = & -2\ 51.217\ (\text{wt.} = 6.98) \\ da = & +0.042 & a = & +\ \ 0.442\ (\text{wt.} = 5.83) \\ dc = & +0.001 & c = & +\ \ 0.151\ (\text{wt.} = 24.00) \end{array}$$

*Ogden, September 17, 1878.*

| Name of star. | Clamp. | T. | | | Bb. | Aa. | Cc. | T'. | | | A. R. | | | ΔT. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| α Cygni | E. | 20 | 40 | 9.95 | − 0.08 | − 0.04 | + 0.24 | 20 | 40 | 10.07 | 20 | 37 | 19.81 | − 2 | 50.76 |
| ε Cygni | E. | 20 | 44 | 9.08 | − 0.07 | + 0.07 | + 0.20 | 20 | 44 | 9.28 | 20 | 41 | 19.76 | 2 | 50.42 |
| α Cephei | E. | 21 | 18 | 33.59 | − 0.12 | − 0.35 | + 0.37 | 21 | 18 | 33.49 | 21 | 15 | 42.94 | 2 | 50.55 |
| ε Pegasi | E. | 21 | 41 | 5.77 | − 0.05 | + 0.25 | + 0.17 | 21 | 41 | 6.14 | 21 | 38 | 15.51 | − 2 | 50.63 |

NORMAL EQUATIONS.

$b_0 = +0^s.37$  $c_0 = +0^s.17$ (assumed correct.)  $\Delta T_0 = -2^m\ 50^s.56$ for $21^h.0$

$$0 = +0^s.087 + 3.26\, d\Delta T + 0.18\, da$$
$$0 = -0.050 + 0.18\, d\Delta T + 0.64\, da$$

$d\Delta T = -0^s.031$  $\Delta T = -2^m\ 50^s.591$ (wt. = 3.21)

$da = +0.09$  $a = +\ 0.46$ (wt. = 0.63)

A night mainly cloudy, with a few clear patches. The value of *c* was taken from observations on neighboring dates, and is quite certain.

### *Ogden, September 20, 1878; before signals.*

| Name of star. | Clamp. | T. | | | B*b*. | A *a*. | C *c*. | T′. | | | A. R. | | | Δ T. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| κ Lyræ | W. | 18 | 18 | 23.65 | 0.00 | + 0.02 | − 0.27 | 18 | 18 | 23.40 | 18 | 15 | 37.38 | − 2 | 46.02 |
| 100 Herculis | W. | | 21 | 18.93 | 0.00 | + 0.06 | − 0.23 | | 21 | 18.76 | 18 | 18 | 32.58 | 2 | 46.18 |
| χ Draconis | W. | | 26 | 1.59 | 0.01 | − 0.28 | − 0.72 | | 26 | 0.58 | 18 | 23 | 14.50 | 2 | 46.08 |
| 9 Heis Lyræ | W. | | 30 | 58.81 | 0.00 | + 0.03 | − 0.25 | | 30 | 58.59 | 18 | 28 | 12.47 | 2 | 46.12 |
| α Lyræ | W. | | 35 | 36.98 | 0.00 | + 0.01 | − 0.28 | | 35 | 36.71 | 18 | 32 | 50.69 | 2 | 46.02 |
| γ Lyræ | E. | 18 | 57 | 11.10 | + 0.01 | + 0.03 | + 0.25 | 18 | 57 | 11.39 | 18 | 54 | 25.37 | 2 | 46.02 |
| ζ Aquilæ | E. | 19 | 2 | 37.03 | + 0.01 | + 0.08 | + 0.22 | 19 | 2 | 37.34 | 18 | 59 | 51.21 | 2 | 46.13 |
| ι Lyræ | E. | | 5 | 45.11 | + 0.02 | + 0.02 | + 0.27 | | 5 | 45.42 | 19 | 2 | 59.39 | 2 | 46.08 |
| 19 Lyræ | E. | | 9 | 53.60 | + 0.01 | + 0.03 | + 0.25 | | 9 | 53.89 | 19 | 7 | 7.91 | 2 | 45.98 |
| δ Draconis | E. | | 15 | 17.85 | + 0.08 | − 0.19 | + 0.56 | | 15 | 18.25 | 19 | 12 | 32.18 | 2 | 46.07 |
| τ Draconis | E. | 19 | 20 | 39.03 | + 0.04 | − 0.30 | + 0.74 | 19 | 20 | 39.51 | 19 | 17 | 53.32 | − 2 | 46.19 |

NORMAL EQUATIONS.

$a_0 = +0^s.20 \qquad c_0 = +0^s.23 \qquad \Delta T_0 = -2^m\ 46^s.07$ for $19^h.0$

$$
\begin{aligned}
&\quad s. \\
0 &= +0.007 + 8.37\, d\Delta T + 0.09\, da + 1.04\, dc \\
0 &= +0.095 + 0.09\, d\Delta T + 2.90\, da - 1.09\, dc \\
0 &= +0.246 + 1.04\, d\Delta T - 1.09\, da + 19.76\, dc
\end{aligned}
$$

$$
\begin{aligned}
&\qquad\quad s. & &\qquad\quad m.\quad s. \\
d\Delta T &= +0.001 & \Delta T &= -\ 2\ 46.069\ (\text{wt.} = 8.31) \\
da &= -0.038 & a &= +\ \ 0.162\ (\text{wt.} = 2.84) \\
dc &= -0.015 & c &= +\ \ 0.215\ (\text{wt.} = 19.21)
\end{aligned}
$$

*Ogden, September 20, 1878; after signals.*

| Name of star. | Clamp. | T. | | | B*b*. | A*a*. | C*c*. | T. | | | A.R. | | | ΔT. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| 11 Cephei | E. | 21 | 42 | 56.01 | + 0.06 | − 0.33 | + 0.77 | 21 | 42 | 56.51 | 21 | 40 | 10.79 | − 2 | 45.72 |
| 16 Pegasi | E. | | 50 | 19.82 | + 0.02 | + 0.07 | + 0.28 | | 50 | 20.19 | 21 | 47 | 34.37 | 2 | 45.82 |
| 17 Pegasi | E. | | 53 | 48.96 | + 0.02 | + 0.11 | + 0.26 | | 53 | 49.35 | 21 | 51 | 3.37 | 2 | 45.98 |
| 20 Pegasi | E. | 21 | 57 | 58.20 | + 0.02 | + 0.11 | + 0.26 | 21 | 57 | 58.59 | 21 | 55 | 12.64 | 2 | 45.95 |
| 27 Pegasi | E. | 22 | 6 | 38.61 | + 0.02 | + 0.04 | + 0.30 | 22 | 6 | 38.97 | 22 | 3 | 53.00 | 2 | 45.97 |
| 24 Cephei | E. | | 10 | 16.42 | + 0.06 | − 0.35 | + 0.81 | | 10 | 16.94 | 22 | 7 | 31.00 | 2 | 45.94 |
| 38 Pegasi | W. | | 27 | 16.99 | 0.00 | + 0.04 | − 0.30 | | 27 | 16.78 | 22 | 24 | 30.88 | 2 | 45.90 |
| Gr. 3804 | W. | | 29 | 52.85 | 0.00 | + 0.01 | − 0.33 | | 29 | 52.58 | 22 | 27 | 6.60 | 2 | 45.98 |
| 31 Cephei | W. | | 35 | 36.58 | + 0.01 | − 0.40 | − 0.87 | | 35 | 35.32 | 22 | 32 | 49.29 | 2 | 46.08 |
| η Pegasi | W. | | 40 | 6.98 | 0.00 | + 0.05 | − 0.29 | | 40 | 6.74 | 22 | 37 | 20.96 | 2 | 45.78 |
| λ Pegasi | W. | 22 | 43 | 29.28 | 0.00 | + 0.07 | − 0.28 | 22 | 43 | 29.07 | 22 | 40 | 43.24 | − 2 | 45.83 |

NORMAL EQUATIONS.

$a_0 = + 0^s.20 \qquad c_0 = + 0^s.23 \qquad \Delta T^0 = - 2^m\ 45^s.90 \qquad \text{for } 22^h.0$

$$\begin{aligned}
&\quad\ \ ^{s.}\\
0 &= - 0.053 + 8.48\, d\,\Delta T + 0.64\, da + 0.92\, dc\\
0 &= - 0.045 + 0.64\, d\,\Delta T + 3.34\, da - 0.80\, dc\\
0 &= - 0.464 + 0.92\, d\,\Delta T - 0.80\, da + 19.41\, dc
\end{aligned}$$

$$\begin{aligned}
&\qquad\ ^{s.} &&\qquad\quad ^{m.\ \ s.}\\
d\,\Delta T &= + 0.002 & \Delta T &= - 2\ 45.898 \ (\text{wt.} = 8.30)\\
da &= + 0.019 & a &= + 0\ \ 0.219 \ (\text{wt.} = 3.25)\\
dc &= + 0.025 & c &= + 0\ \ 0.255 \ (\text{wt.} = 19.08)
\end{aligned}$$

*Ogden, September 21, 1878; before signals.*

| Name of star. | Clamp. | T. | | | B *b*. | A *a*. | C *c*. | T′. | | | A. R. | | | ΔT. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| χ Draconis | W. | 18 | 25 | 59.95 | − 0.09 | − 0.37 | − 0.52 | 18 | 25 | 58.97 | 18 | 23 | 14.59 | − 2 | 44.38 |
| α Lyræ | W. | | 35 | 35.00 | − 0.04 | + 0.01 | − 0.20 | | 35 | 34.77 | 18 | 32 | 50.66 | 2 | 44.11 |
| β Lyræ | W. | | 48 | 21.16 | − 0.04 | + 0.03 | − 0.19 | | 48 | 20.96 | 18 | 45 | 36.92 | 2 | 44.04 |
| δ² Lyræ | W. | | 53 | 0.96 | − 0.04 | + 0.02 | − 0.19 | | 53 | 0.75 | 18 | 50 | 16.55 | 2 | 44.20 |
| γ Lyræ | W. | 18 | 57 | 9.63 | − 0.04 | + 0.04 | − 0.18 | 18 | 57 | 9.45 | 18 | 54 | 25.35 | 2 | 44.10 |
| τ Draconis | E. | 19 | 20 | 37.22 | − 0.04 | − 0.38 | + 0.53 | 19 | 20 | 37.33 | 19 | 17 | 53.24 | 2 | 44.09 |
| 4 Cygni | E. | | 24 | 31.94 | − 0.01 | + 0.02 | + 0.19 | | 24 | 32.14 | 19 | 21 | 48.08 | 2 | 44.11 |
| β Cygni | E. | | 28 | 34.90 | − 0.01 | + 0.06 | + 0.17 | | 28 | 35.12 | 19 | 25 | 50.92 | 2 | 44.20 |
| 9 Cygni | E. | | 32 | 46.77 | − 0.01 | + 0.05 | + 0.18 | | 32 | 46.99 | 19 | 30 | 2.79 | 2 | 44.20 |
| φ Cygni | E. | | 37 | 20.31 | − 0.01 | + 0.05 | + 0.18 | | 37 | 20.53 | 19 | 34 | 36.22 | 2 | 44.31 |
| 28 Hels Cygni | E. | | 40 | 49.59 | − 0.01 | + 0.04 | + 0.18 | | 40 | 49.80 | | | | | |
| ε Draconis | E. | 19 | 51 | 19.58 | − 0.03 | − 0.29 | + 0.45 | 19 | 51 | 19.71 | 19 | 48 | 35.67 | − 2 | 44.04 |

NORMAL EQUATIONS.

$a_0 = +\,0^s.25 \qquad c_0 = +\,0^s.18 \qquad \Delta\,T_0 = -\,2^m\ 44^s.16 \qquad \text{for } 19^h.0$

$$
\begin{aligned}
& \quad\ \ s. \\
0 &= +\,0.024 + 8.24\, d\,\Delta\,T - 0.29\, da + 0.94\, dc \\
0 &= +\,0.088 - 0.29\, d\,\Delta\,T + 2.83\, da - 1.15\, dc \\
0 &= +\,0.466 + 0.94\, d\,\Delta\,T - 1.15\, da + 20.24\, dc
\end{aligned}
$$

$$
\begin{array}{rlrl}
 & s. & & m.\ \ s. \\
d\,\Delta\,T = & -\,0.002 & \Delta\,T = & -\,2\ 44.162\ (\text{wt.} = 8.18) \\
da = & -\,0.041 & a = & +\ \ 0.209\ (\text{wt.} = 2.75) \\
dc = & -\,0.025 & c = & +\ \ 0.155\ (\text{wt.} = 19.68)
\end{array}
$$

*Ogden, September* 21, 1878; *after signals.*

| Name of star. | Clamp. | T. | | | B*b*. | A*a*. | C*c*. | T′. | | | A. R. | | | T. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| 11 Cephei | E. | 21 | 42 | 54.42 | + 0.09 | − 0.38 | + 0.58 | 21 | 42 | 54.71 | 21 | 40 | 10.75 | − 2 | 43.96 |
| 16 Pegasi | E. | | 50 | 18.15 | + 0.04 | + 0.08 | + 0.21 | | 50 | 18.48 | 21 | 47 | 34.36 | 2 | 44.12 |
| 17 Pegasi | E. | | 53 | 47.00 | + 0.03 | + 0.18 | + 0.20 | | 53 | 47.36 | 21 | 51 | 3.37 | 2 | 43.99 |
| 20 Pegasi | E. | 21 | 57 | 56.37 | + 0.03 | + 0.12 | + 0.20 | | 57 | 56.72 | 21 | 55 | 12.63 | 2 | 44.09 |
| 27 Pegasi | E. | 22 | 6 | 36.68 | + 0.04 | + 0.05 | + 0.23 | 21 | 6 | 37.00 | 22 | 3 | 52.99 | 2 | 44.01 |
| 24 Cephei | E. | | 10 | 14.74 | + 0.10 | − 0.41 | + 0.61 | 22 | 10 | 15.04 | 22 | 7 | 30.97 | 2 | 44.07 |
| 38 Pegasi | W. | | 27 | 14.97 | − 0.02 | + 0.05 | − 0.23 | | 27 | 14.77 | 22 | 24 | 30.82 | 2 | 43.95 |
| Gr. 3804 | W. | | 29 | 50.94 | − 0.02 | + 0.01 | − 0.25 | | 29 | 50.68 | 22 | 27 | 6.59 | 2 | 44.09 |
| 31 Cephei | W. | | 35 | 34.51 | − 0.04 | − 0.46 | − 0.66 | | 35 | 33.35 | 22 | 32 | 49.27 | 2 | 44.08 |
| η Pegasi | W. | | 45 | 5.09 | − 0.02 | + 0.06 | − 0.22 | | 40 | 4.91 | 22 | 37 | 20.96 | 2 | 43.95 |
| λ Pegasi | W. | 22 | 43 | 27.48 | − 0.02 | + 0.09 | − 0.21 | 22 | 43 | 27.34 | 22 | 40 | 43.23 | − 2 | 44.11 |

NORMAL EQUATIONS.

$a_0 = +0^s.25 \qquad c_0 = +0^s.20 \qquad \Delta T_0 = -2^m\ 44^s.00$ for $22^h.0$

$$
\begin{aligned}
0 &= +\overset{s.}{0.319} + 8.48\, d\Delta T + 0.64\, da + 0.92\, dc \\
0 &= +0.004 + 0.64\, d\Delta T + 3.35\, da - 0.80\, dc \\
0 &= +0.196 + 0.92\, d\Delta T - 0.80\, da + 19.41\, dc
\end{aligned}
$$

$$
\begin{aligned}
d\Delta T &= -\overset{s.}{0.038} \quad \Delta T = -\overset{m.}{2}\ \overset{s.}{44.038}\ (\text{wt.} = 8.30) \\
da &= +0.004 \quad a = +\ 0.254\ (\text{wt.} = 3.26) \\
d &= \phantom{+}0.008 \quad c = +\ 0.192\ (\text{wt.} = 19.08)
\end{aligned}
$$

*Ogden, September 22, 1878; before signals.*

| Name of star. | Clamp. | T. | B *b*. | A *a*. | C *c*. | T′. | A. R. | Δ T. |
|---|---|---|---|---|---|---|---|---|
| | | *h.* *m.* *s.* | *s.* | *s.* | *s.* | *h.* *m.* *s.* | *h.* *m.* *s.* | *m.* *s.* |
| a Lyræ | W. | 18 18 19.92 | + 0.14 | + 0.03 | − 0.27 | 18 18 19.82 | 18 15 37.38 | − 2 42.49 |
| 109 Herculis | W. | 21 15.31 | + 0.10 | + 0.09 | − 0.23 | 21 15.27 | 18 18 32.54 | 2 42.73 |
| χ Draconis | W. | 25 57.70 | + 0.26 | − 0.45 | − 0.72 | 25 56.79 | 18 23 14.39 | 2 42.40 |
| 9 Heis Lyræ | W. | 30 55.16 | + 0.08 | + 0.06 | − 0.25 | 30 55.05 | 18 28 12.42 | 2 42.63 |
| α Lyræ | W. | 35 33.30 | + 0.08 | + 0.01 | − 0.28 | 35 33.11 | 18 32 50.64 | 2 42.47 |
| γ Lyræ | E. | 18 57 7.31 | + 0.05 | + 0.05 | + 0.25 | 18 57 7.66 | 18 54 25.32 | 2 42.34 |
| ζ Aquilæ | E. | 19 2 33.37 | + 0.04 | + 0.12 | + 0.22 | 19 2 33.75 | 18 59 51.18 | 2 42.57 |
| ι Lyræ | E. | 5 41.47 | + 0.05 | + 0.03 | + 0.27 | 5 41.82 | 19 2 59.34 | 2 42.48 |
| 19 Lyræ | E. | 9 50.10 | + 0.05 | + 0.05 | + 0.25 | 9 50.45 | 19 7 7.87 | 2 42.58 |
| δ Draconis | E. | 15 14.15 | + 0.10 | − 0.29 | + 0.56 | 15 14.52 | 19 12 32.06 | 2 42.46 |
| τ Draconis | E. | 19 20 35.65 | + 0.13 | − 0.47 | + 0.74 | 19 20 36.05 | 19 17 53.17 | − 2 42.88 |

NORMAL EQUATIONS.

$a_0 + 0^s.30 \qquad c_0 = + 0^s.20 \qquad \Delta T_0 = - 2^m\ 42^s.54$ for $19^h.0$

$$\begin{aligned}
&\quad\ \ s.\\
0 &= - 0.005 + 8.88\, d\,\Delta T + 0.09\, da + 1.05\, dc\\
0 &= + 0.144 + 0.09\, d\,\Delta T + 2.89\, da - 1.08\, dc\\
0 &= - 0.337 + 1.05\, d\,\Delta T - 1.68\, da + 19.76\, dc
\end{aligned}$$

$$\begin{aligned}
&\qquad\quad s. &&\qquad\quad m.\quad s.\\
d\,\Delta T\ &\Delta - 0.001 & \Delta T &= - 2\ 42.541\ (\text{wt.} = 8.31)\\
da\ &\Delta - 0.044 & a &= +\ \ 0.256\ (\text{wt.} = 2.83)\\
dc\ &\Delta + 0.015 & c &= +\ \ 0.215\ (\text{wt.} = 19.22)
\end{aligned}$$

*Ogden, September 22, 1878; after signals.*

| Name of star. | Clamp | T. | B *b*. | A *a*. | C *c*. | T'. | A. R. | Δ T. |
|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *h. m. s.* | *m. s.* |
| 27 Pegasi | E. | 22 6 34.91 | + 0.14 | + 0.07 | + 0.22 | 22 6 35.34 | 22 3 52.98 | − 2 42.36 |
| 24 Cephei | E. | 10 12.92 | + 0.32 | − 0.60 | + 0.59 | 10 13.23 | 22 7 30.93 | 2 42.30 |
| 1 Lacertæ | E. | 13 24.50 | + 0.15 | + 0.03 | + 0.23 | 13 24.91 | 22 10 42.74 | 2 42.17 |
| 31 Pegasi | E. | 18 16.65 | + 0.11 | + 0.19 | + 0.19 | 18 17.14 | 22 15 34.73 | 2 42.41 |
| Gr. 3804 | W. | 29 49.12 | + 0.07 | + 0.02 | − 0.24 | 29 48.97 | 22 27 6.59 | 2 42.38 |
| Pi. XXII, 158 | W. | 32 43.02 | + 0.05 | + 0.14 | − 0.19 | 32 43.02 | ........ | ........ |
| 31 Cephei | W. | 35 32.74 | + 0.16 | − 0.67 | − 0.64 | 35 31.59 | 22 32 49.24 | 2 42.35 |
| η Pegasi | W. | 40 3.16 | + 0.06 | + 0.08 | − 0.21 | 40 3.09 | 22 37 20.93 | 2 42.16 |
| λ Pegasi | W. | 22 43 25.59 | + 0.06 | + 0.13 | − 0.20 | 22 43 25.58 | 22 40 43.23 | − 2 42.35 |

NORMAL EQUATIONS.

$a_0 = +0^s.40 \qquad c_0 = +0^s.20 \qquad \Delta T_0 = -2^m\,42^s.81 \text{ for } 22^h.4$

$$\begin{aligned} &\phantom{=}\;\; s. \\ 0 &= -0.007 + 6.15\,d\Delta T + 0.29\,da + 0.00\,dc \\ 0 &= +0.070 + 0.29\,d\Delta T + 2.23\,da + 0.26\,dc \\ 0 &= +0.199 + 0.00\,d\Delta T + 0.26\,da + 14.15\,dc \end{aligned}$$

$$\begin{aligned} d\Delta T &= +0.003^s & \Delta T &= -2^m\,42^s.307 \text{ (wt. = 6.11)} \\ da &= -0.030 & a &= +\;0.370 \text{ (wt. = 2.21)} \\ dc &= -0.014 & c &= +\;0.186 \text{ (wt. = 14.12)} \end{aligned}$$

(FORM No. 12.)

| Signals sent from— | Recorded at— | Mean of signals sent and received. | Time correction. | Corrected time. | Difference of longitude. | Double wave time. | Means. |
|---|---|---|---|---|---|---|---|
| | | h. m. s. | m. s. | h. m. s. | m. s. | s. | m. s. |
| September 5, 1878: | | | | | | | |
| Ogden | Ogden | 20 11 50.00 | — 2 51.044 | 20 8 58.956 | | | |
| | Dalles | 19 32 19.44 | — 10.944 | 19 32 8.496 | 36 50.460 | | |
| Dalles | Ogden | 20 16 20.22 | — 2 51.056 | 20 13 29.164 | | | |
| | Dalles | 19 36 49.60 | — 10.944 | 19 36 38.656 | 36 50.508 | + 0.048 | 36 50.484 |
| September 17, 1878: | | | | | | | |
| Ogden | Ogden | 21 26 50.00 | — 2 50.569 | 21 23 59.431 | | | |
| | Dalles | 20 47 16.27 | — 5.851 | 20 47 10.419 | 36 49.012 | | |
| Dalles | Ogden | 21 31 29.17 | — 2 50.566 | 21 28 38.604 | | | |
| | Dalles | 20 51 55.20 | — 5.851 | 20 51 49.349 | 36 49.255 | + 0.243 | 36 49.134 |
| September 20, 1878: | | | | | | | |
| Ogden | Ogden | 21 26 35.00 | — 2 45.907 | 21 23 49.093 | | | |
| | Dalles | 20 47 6.49 | — 6.826 | 20 46 59.664 | 36 49.429 | | |
| Dalles | Ogden | 21 30 22.95 | — 2 45.902 | 21 27 37.048 | | | |
| | Dalles | 20 50 54.20 | — 6.826 | 21 50 47.374 | 36 49.674 | + 0.245 | 36 49.552 |
| September 21, 1878: | | | | | | | |
| Ogden | Ogden | 21 24 5.00 | — 2 44.031 | 21 21 20.969 | | | |
| | Dalles | 20 44 38.02 | — 6.637 | 20 44 31.383 | 36 49.586 | | |
| Dalles | Ogden | 21 27 47.44 | — 2 44.026 | 21 25 3.414 | | | |
| | Dalles | 20 48 20.10 | — 6.636 | 20 48 13.464 | 36 49.950 | + 0.364 | 36 49.768 |
| September 22, 1878: | | | | | | | |
| Ogden | Ogden | 21 42 30.00 | — 2 42.347 | 21 39 47.653 | | | |
| | Dalles | 21 3 4.44 | — 6.280 | 21 2 58.160 | 36 49.493 | | |
| Dalles | Ogden | 21 46 19.21 | — 2 42.343 | 21 43 36.867 | | | |
| | Dalles | 21 6 53.30 | — 6.280 | 21 6 47.020 | 36 49.847 | + 0.354 | 36 49.670 |

| | | | |
|---|---|---|---|
| | m. | s. | |
| Final difference of longitude, | 36 | 49.722 | |
| | ° | ′ | ″ |
| = | 9 | 12 | 25.83 |
| Add longitude of Ogden, | 111 | 59 | 54.64 |
| longitude of Dalles, | 121 | 12 | 20.47 |

*Mean place of stars for* 1878.0 *used for the determination of latitude of The Dalles, Oreg.*

| No. of combination. | No. B. A. C. | Class. | R. A. |  |  | Declination. |  |  |
|---|---|---|---|---|---|---|---|---|
|  |  |  | *h.* | *m.* | *s.* | ° | ′ | ″ |
| 1 | (1) | B | 18 | 5 | 18 | 66 | 55 | 45.9 |
|  | 6223 | A | 18 | 14 | 10 | 24 | 23 | 47.6 |
| 2 | 6246 | B | 18 | 17 | 5 | 51 | 17 | 41.5 |
|  | 6262 | A |  | 20 | 13 | 39 | 26 | 30.0 |
| 3 | 6255 | A | 18 | 18 | 25 | 49 | 3 | 38.8 |
|  | (2) | B | 18 | 20 | 24 | 42 | 24 | 7.0 |
| 4 | 6335 | B | 18 | 29 | 24 | 52 | 1 | 28.3 |
|  | 6357 | B | 18 | 34 | 5 | 39 | 33 | 42.1 |
| 5 | 6372 | A | 18 | 37 | 5 | 52 | 4 | 54.1 |
|  | (3) | B | 18 | 39 | 12 | 39 | 10 | 43.1 |
|  | (4) | C | 18 | 36 | 4 | 52 | 14 | 1.1 |
|  | 6390 | A | 18 | 40 | 18 | 39 | 32 | 35.9 |
|  | 6391 | A | 18 | 40 | 20 | 39 | 29 | 9.0 |
| 6 | 6428 | B | 18 | 45 | 3 | 48 | 37 | 44.5 |
|  | (5) | A | 18 | 49 | 40 | 42 | 45 | 8.1 |
| 7 | 6427 | A | 18 | 45 | 20 | 32 | 24 | 41.1 |
|  | 6463 | A A | 18 | 49 | 24 | 59 | 14 | 22.2 |
| 8 | 6468 | A | 18 | 50 | 24 | 33 | 48 | 49.6 |
|  | 6477 | C | 18 | 51 | 39 | 57 | 19 | 56.0 |
|  | 6496 | B | 18 | 54 | 41 | 57 | 39 | 12.8 |
| 9 | 6522 | B | 18 | 58 | 18 | 55 | 29 | 2.2 |
|  | 6556 | A | 19 | 2 | 57 | 35 | 54 | 35.3 |
| 10 | 6599 | A | 19 | 12 | 8 | 37 | 55 | 1.9 |
|  | 6623 | A A | 19 | 14 | 17 | 53 | 8 | 38.0 |
| 11 | (6) | C | 19 | 18 | 48 | 64 | 9 | 36.1 |
|  | 6690 | A | 19 | 25 | 48 | 27 | 42 | 16.3 |
|  | 6691 | A | 19 | 25 | 50 | 27 | 42 | 35.7 |
| 12 | 6717 | C | 19 | 30 | 20 | 48 | 59 | 50.8 |
|  | 6718 | C | 19 | 30 | 43 | 42 | 8 | 47.1 |
| 13 | 6730 | A | 19 | 32 | 40 | 49 | 57 | 56.5 |
|  | 6734 | A | 19 | 33 | 10 | 49 | 56 | 21.1 |
|  | 6769 | C | 19 | 39 | 41 | 41 | 28 | 52.0 |
| 14 | 6741 | C | 19 | 34 | 33 | 49 | 0 | 9.0 |
|  | 6745 | B | 19 | 35 | 28 | 42 | 32 | 14.1 |
| 15 | 6780 | C | 19 | 40 | 52 | 57 | 43 | 33.9 |
|  | 6784 | A | 19 | 41 | 48 | 33 | 26 | 40.7 |
|  | 6800 | C | 19 | 44 | 11 | 33 | 7 | 58.9 |
| 16 | 6806 | B | 19 | 45 | 8 | 38 | 24 | 13.5 |
|  | 6813 | B | 19 | 46 | 15 | 38 | 24 | 33.6 |
|  | 6824 | B | 19 | 47 | 34 | 52 | 40 | 43.8 |
|  | 6856 | A | 19 | 52 | 28 | 52 | 6 | 56.1 |
| 17 | 6881 | C | 19 | 56 | 2 | 51 | 43 | 19.3 |
|  | 6918 | C | 20 | 1 | 48 | 51 | 29 | 24.7 |
|  | 6959 | B | 20 | 9 | 8 | 51 | 5 | 50.2 |
|  | 6986 | B | 20 | 12 | 35 | 39 | 59 | 18.0 |
|  | 7022 | A | 20 | 17 | 51 | 39 | 52 | 1.3 |
| 18 | 7029 | A | 20 | 18 | 59 | 31 | 47 | 49.3 |
|  | 7060 | B | 20 | 22 | 33 | 59 | 12 | 6.3 |
| 19 | 7064 | B | 20 | 23 | 26 | 56 | 14 | 13.4 |
|  | 7105 | C | 20 | 28 | 48 | 56 | 21 | 57.9 |
|  | 7103 | A | 20 | 29 | 9 | 34 | 50 | 2.0 |
| 20 | 7153 | C | 20 | 33 | 45 | 52 | 32 | 51.6 |
|  | 7167 | C | 20 | 36 | 26 | 38 | 38 | 54.4 |
|  | 7218 | B | 20 | 42 | 49 | 52 | 33 | 4.8 |
| 21 | 7332 | C | 21 | 0 | 4 | 52 | 48 | 1.7 |
|  | 7336 | AA | 21 | 1 | 26 | 38 | 9 | 1.3 |
|  | 7337 | AA | 21 | 1 | 27 | 38 | 8 | 52.2 |
|  | 7365 | A | 21 | 6 | 29 | 53 | 3 | 55.3 |
| 22 | 7373 | B | 21 | 8 | 32 | 36 | 7 | 49.6 |
|  | 7401 | B | 21 | 13 | 35 | 55 | 17 | 9.5 |
|  | 7453 | A | 21 | 20 | 48 | 36 | 8 | 27.3 |
| 23 | 7505 | A | 21 | 29 | 48 | 37 | 59 | 15.8 |
|  | 7530 | C | 21 | 33 | 35 | 58 | 29 | 34.7 |
|  | 7566 | A | 21 | 38 | 23 | 37 | 43 | 32.5 |
|  | (7) | B | 21 | 38 | 34 | 37 | 44 | 50.3 |
| 24 | 7614 | B | 21 | 46 | 2 | 38 | 57 | 57.5 |
|  | 7646 | C | 21 | 51 | 13 | 52 | 39 | 53.8 |
|  | 7676 | B | 21 | 57 | 22 | 52 | 17 | 40.2 |
| 25 | 7718 | C | 22 | 3 | 3 | 58 | 14 | 43.9 |
|  | 7721 | A | 22 | 3 | 49 | 32 | 34 | 36.4 |
|  | 7731 | A | 22 | 4 | 34 | 32 | 34 | 47.9 |
|  | 7736 | B | 22 | 4 | 28 | 58 | 41 | 45.5 |
|  | 7755 | B | 22 | 7 | 22 | 58 | 48 | 46.9 |
| 26 | 7749 | A | 22 | 6 | 37 | 57 | 36 | 0.8 |
|  | 7753 | B | 22 | 7 | 24 | 34 | 0 | 12.7 |
| 27 | 7770 | C | 22 | 9 | 37 | 42 | 20 | 58.3 |
|  | 7820 | B | 22 | 19 | 34 | 48 | 51 | 29.1 |
|  | 7850 | B | 22 | 25 | 13 | 42 | 29 | 54.2 |
| 28 | 7888 | B | 22 | 32 | 22 | 50 | 54 | 56.2 |
|  | 7917 | C | 22 | 36 | 9 | 40 | 54 | 36.1 |
| 29 | 7995 | B | 22 | 51 | 5 | 49 | 4 | 56.6 |
|  | 8028 | B | 22 | 56 | 59 | 42 | 6 | 5.8 |
|  | 8036 | A | 22 | 58 | 42 | 49 | 23 | 20.8 |
| 30 | 8059 | B | 23 | 2 | 18 | 48 | 37 | 52.9 |
|  | 8076 | B | 23 | 4 | 49 | 42 | 53 | 20.9 |
|  | 8082 | A | 23 | 6 | 58 | 48 | 44 | 23.7 |
|  | 8114 | B | 23 | 12 | 5 | 48 | 20 | 57.8 |
| 31 | 8125 | A | 23 | 13 | 49 | 47 | 57 | 22.8 |
|  | 8135 | B | 23 | 14 | 58 | 43 | 26 | 59.1 |
| 32 | 8153 | B | 23 | 17 | 6 | 59 | 27 | 53.4 |
|  | 8159 | A | 23 | 18 | 53 | 31 | 42 | 53.7 |

---

[1] Sd. 745. [2] Sd. 779. [3] Sd. 812. [4] Sd. 806. [5] Sd. 843. [6] Sd. 923. [7] Sd. 1364.

*Observations and computations for latitude, of The Dalles, Oregon.*

| Date. | Number of star. | Micrometer readings. | Level. |  | Half sum of declination. | Corrections. |  |  | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | N. | S. |  | Micr. and refr. | Level. | Merid. |  |
|  |  |  |  |  | ° ′ ″ | ′ ″ | ″ |  | ° ′ ″ |
| September 5, 1878.... | 6246<br>6268 | 5.845<br>26.658 | 19.5<br>9 | 12<br>22 | 45 22 18.5 | +14 2.9 | −2.0 | ........ | 45 36 19.4 |
|  | 6335<br>6357 | 25.520<br>8.468 | 17<br>13 | 15<br>18 | 45 47 48.9 | −11 30.6 | −1.1 | ........ | 17.2 |
|  | 6372<br>(3) | 13.370<br>10.785 | 16<br>14.5 | 15<br>17 | 45 38 2.6 | −1 44.7 | −0.5 | ........ | 17.4 |
|  | 6427<br>6463 | 3.490<br>23.395 | 17<br>9 | 15<br>23.5 | 45 49 45.8 | −13 26.2 | −4.5 | ........ | 15.1 |
|  | 6522<br>6556 | 20.765<br>12.300 | 15.5<br>13.5 | 16<br>18 | 45 42 3.9 | − 5 42.8 | −1.8 | ........ | 19.3 |
|  | 6599<br>6623 | 21.095<br>14.773 | 16.5<br>12.5 | 15<br>19.5 | 45 32 5.9 | + 4 16.0 | −2.0 | ........ | 19.9 |
| September 6, 1878.... | (1)<br>6223 | 19.880<br>14.360 | 16.5<br>20 | 18<br>14 | 45 39 58.6 | − 3 43.6 | +1.6 | ........ | 16.0 |
|  | 6335<br>6357 | 24.595<br>7.440 | 14.5<br>19 | 20<br>16 | 45 47 49.0 | −11 34.8 | −0.9 | ........ | 13.3 |
|  | 6427<br>6463 | 6.425<br>26.485 | 13<br>26 | 22<br>9 | 45 49 46.0 | −13 32.4 | +2.9 | ........ | 16.5 |
|  | 6522<br>6556 | 19.760<br>11.135 | 19<br>20 | 16.5<br>15 | 45 42 4.0 | − 5 49.3 | +2.7 | ........ | 17.4 |
|  | 6599<br>6623 | 21.055<br>14.870 | 16.5<br>21.5 | 19<br>14 | 45 32 6.0 | + 4 10.5 | +1.8 | ........ | 18.3 |
|  | (6)<br>6690<br>6691 | 31.755<br>2.195<br>1.955 | 20.5<br>......<br>17 | 15<br>......<br>19 | 45 56 17.0 | −20 2.0 | +1.3 | ........ | 16.3 |
|  | 6730<br>6734<br>6769 | 21.260<br>20.070<br>10.180 | ......<br>17.5<br>22.5 | ......<br>18<br>13 | 45 43 17.8 | − 7 4.4 | +3.2 | ........ | 16.6 |
|  | 6780<br>6784<br>6800 | 12.505<br>13.795<br>27.640 | 16.5<br>21.5<br>...... | 19<br>14<br>...... | 45 30 44.1 | + 5 32.6 | +1.8 | ........ | 18.5 |
|  | 6813<br>6824<br>6856 | 29.725<br>24.825<br>*− 0.700 | 18<br>......<br>20 | 18<br>......<br>16 | 45 24 29.6 | +11 47.2 | +1.4 | ........ | 18.2 |
|  | 6881<br>6918<br>6959<br>6986<br>7022 | 30.080<br>19.735<br>2.255<br>7.285<br>12.670 | 21<br>......<br>......<br>18<br>...... | 15<br>......<br>......<br>18<br>...... | 45 41 14.3 | − 4 58.9 | +2.2 | ........ | 17.6 |
|  | 7029<br>7060 | 18.275<br>9.330 | 19.5<br>19 | 17<br>17 | 45 30 16.7 | + 6 2.3 | +1.6 | ........ | 20.6 |
|  | 7064<br>7103 | 12.920<br>18.575 | 18<br>19.5 | 18<br>17 | 45 32 27.0 | + 3 49.0 | +0.9 | ........ | 16.9 |
|  | 7153<br>7167<br>7218 | 15.330<br>15.410<br>15.590 | 18<br>21<br>{19<br>{21 | 18<br>16<br>18<br>16 | 45 36 16.1 | − 0 2.0 | +2.8 | ........ | 16.4 |
|  | 7332<br>7336<br>7337<br>7365 | 8.360<br>19.290<br>19.410<br>20.240 | 20<br>......<br>19<br>...... | 18.5<br>......<br>18<br>...... | 45 32 49.3 | + 8 24.5 | +1.3 | ........ | 15.1 |
|  | 7373<br>7401<br>7453 | 10.475<br>20.305<br>10.035 | {18<br>{24<br>...... | 19<br>13<br>...... | 45 42 59.8 | − 6 47.0 | +3.6 | ........ | 45 36 16.4 |

*Reading, −1 +.700.

*Observations and computations for latitude of The Dalles, Oregon.*

| Date. | Number of star. | Micrometer readings. | Level. | | Half sum of declination. | Corrections. | | | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
| | | | N. | S. | | Micr. and refr. | Level. | Merid. | |
| | | | | | ° ′ ″ | ′ ″ | ″ | | ° ′ ″ |
| September 6, 1878.... | 7505 | 8.155 | 16 | 21.5 | 45 40 50.7 | − 4 38.0 | +2.4 | ........ | 45 36 15.1 |
| | 7530 | 20.855 | 25 | 12 | | | | | |
| | 7566 | 19.825 | 15<br>25 | 22<br>12 | | | | | |
| | 7614 | 8.460 | 18 | 19 | 45 43 43.7 | − 7 31.6 | +4.0 | ........ | 16.1 |
| | 7646 | 27.860 | 25 | 13 | | | | | |
| | 7676 | 11.360 | ...... | ...... | | | | | |
| | 7749 | 27.060 | 21 | 17 | 45 48 28.3 | −12 13.9 | +2.2 | ........ | 16.6 |
| | 7753 | 8.940 | 20 | 18 | | | | | |
| | 7770 | 2.045 | 18 | 19 | 45 36 35.5 | − 0 20.7 | +3.2 | ........ | 18.0 |
| | 7820 | 2.555 | 24 | 14 | | | | | |
| | 7888 | 28.455 | 20 | 17.5 | 45 55 7.9 | −18 54.6 | +2.7 | ........ | 16.0 |
| | 7917 | *− 0.440 | 21.5 | 16.5 | | | | | |
| | 7995 | 14.040 | 20 | 18 | 45 40 29.0 | − 4 15.4 | +3.2 | ........ | 16.8 |
| | 8028 | 14.570 | 21.5 | 16.5 | | | | | |
| | 8036 | 27.710 | 22 | 16 | | | | | |
| | 8059 | 20.965 | 17 | 21.5 | 45 41 44.7 | − 5.32.0 | +3.2 | ........ | 15.9 |
| | 8076 | 6.425 | 26.5 | 12 | | | | | |
| | †8082 | 25.720 | 16 | 22.5 | | | | | |
| | 8114 | 8.280 | ...... | ...... | | | | | |
| | 8125 | 20.220 | 18.5 | 20 | 45 42 32.5 | − 6 19.9 | +2.3 | ........ | 14.9 |
| | 8135 | 10.840 | 23 | 15 | | | | | |
| | 8153 | ‡20.485 | 19 | 19.5 | 45 35 44.9 | − 0 31.2 | +2.3 | ........ | 16.0 |
| | 8159 | 16.255 | 22.5 | 15.5 | | | | | |
| September 7, 1878.... | (1) | 20.350 | 19 | 18 | 45 39 58.1 | − 3 46.6 | +1.8 | ........ | 13.3 |
| | 6223 | 14.755 | 20.5 | 16.5 | | | | | |
| | 6255 | 23.708 | 21.5 | 16 | 45 44 6.0 | − 7 50.3 | +3.1 | ........ | 18.8 |
| | (2) | 12.095 | 20 | 17 | | | | | |
| | 6335 | 23.755 | 18 | 19 | 45 47 49.1 | −11 35.4 | +2.3 | ........ | 16.0 |
| | 6357 | 6.585 | 22.5 | 15 | | | | | |
| | 6372 | 13.350 | 20 | 17.5 | 45 38 2.8 | − 1 50.0 | +2.5 | ........ | 15.3 |
| | (3) | 10.635 | 21 | 16.5 | | | | | |
| | 6427 | 5.130 | 19.5 | 17.5 | 45 49 46.1 | −13 33.0 | +2.7 | ........ | 15.8 |
| | 6463 | 25.205 | 21.5 | 16 | | | | | |
| | 6468 | 12.905 | 18 | 19.5 | 45 44 16.0 | − 8 0.9 | +3.4 | ........ | 18.5 |
| | 6496 | 24.780 | 24 | 13 | | | | | |
| | 6522 | 23.065 | 18 | 19 | 45 42 4.2 | − 5 50.3 | +3.4 | ........ | 17.3 |
| | 6556 | 14.415 | 24 | 13.5 | | | | | |
| | 6599 | 13.560 | 19 | 19 | 45 32 6.2 | + 4 13.5 | −0.5 | ........ | 19.2 |
| | 6623 | 7.300 | 18 | 19.5 | | | | | |
| | 6717 | 16.080 | ...... | ...... | 45 34 35.8 | + 1 42.5 | −0.2 | ........ | 18.1 |
| | 6718 | 18.610 | ...... | ...... | | | | | |
| | 6741 | 24.560 | 17 | 21 | 45 46 29.2 | −10 12.6 | 0.0 | ........ | 16.6 |
| | 6745 | 9.435 | 21 | 17 | | | | | |
| | 6780 | 11.865 | 19 | 19 | 45 30 44.3 | + 5 34.9 | −0.4 | ........ | 18.8 |
| | 6784 | 13.210 | 18.5 | 19.5 | | | | | |
| | 6800 | 27.060 | ...... | ...... | | | | | |
| | 6806 | 28.665 | ...... | ...... | 45 24 24.8 | +11 54.4 | 0.0 | ........ | 19.2 |
| | 6813 | 28.420 | 19 | 18 | | | | | |
| | 6324 | 23.430 | ...... | ...... | | | | | |
| | 6856 | §−3.375 | 18.5 | 19.5 | | | | | |
| | 6881 | 31.350 | 18.5 | 19.5 | 45 41 14.2 | − 4 57.0 | +0.2 | ........ | 45 36 17.4 |
| | 6918 | 21.040 | 20 | 18 | | | | | |
| | 6959 | 3.535 | 18 | 20 | | | | | |
| | 6986 | 8.595 | 20 | 18 | | | | | |
| | 7022 | 14.020 | ...... | ...... | | | | | |

Probably 0 440. 8082 in error; cannot find what the error is. ‡ 15$^r$.485. § Should be −2$^r$ +.375.

*Observations and computations for latitude of The Dalles, Oreg.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. | | Half sum of declination. | Corrections. | | | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
| | | | N. | S. | | Micr. and refr. | Level. | Merid. | |
| | | | | | ° ′ ″ | ′ ″ | ″ | | ° ′ ″ |
| September 7, 1878.... | 7029 | 18.780 | 19 | 19 | 45 30 16.9 | + 6 0.0 | +1.4 | ........ | 45 36 18.3 |
| | 7060 | 9.890 | 21 | 17 | | | | | |
| | 7153 | 15.830 | 19.5 | 19 | 45 36 16.3 | + 0 1.8 | +0.1 | ........ | 18.2 |
| | 7167 | 15.970 | 19 | 20 | | | | | |
| | 7218 | 16.020 | 19<br>20 | 20<br>18 | | | | | |
| | 7332 | 8.095 | 21 | 18 | 45 32 49.5 | + 3 26.4 | +1.6 | ........ | 17.5 |
| | 7336 | 19.015 | 20.5 | 19 | | | | | |
| | 7337 | 19.115 | ...... | ...... | | | | | |
| | 7365 | 19.840 | ...... | ...... | | | | | |
| | 7373 | 11.395 | 19.5 | 19 | 45 43 0.1 | − 6 44.9 | +1.4 | ........ | 16.6 |
| | 7401 | 21.155 | 21.5 | 18 | | | | | |
| | 7453 | 10.920 | ...... | ...... | | | | | |
| | 7505 | 6.220 | 21 | 18 | 45 40 51.0 | − 4 35.7 | +1.1 | ........ | 16.4 |
| | 7530 | 18.850 | 20 | 20 | | | | | |
| | 7566 | 17.865 | ...... | ...... | | | | | |
| | 7614 | 8.225 | 19.5 | 20 | 45 43 44.0 | − 7 27.1 | +0.9 | ........ | 17.8 |
| | 7646 | 27.495 | 21 | 18 | | | | | |
| | 7676 | 11.035 | ...... | ...... | | | | | |
| | 7718 | 2.415 | ...... | ...... | 45 35 12.9 | + 1 4.3 | +0.8 | ........ | 18.0 |
| | 7721 | 19.096 | ...... | ...... | | | | | |
| | 7731 | 18.950 | ...... | ...... | | | | | |
| | 7736 | 22.270 | ...... | ...... | | | | | |
| | 7755 | 27.620 | ...... | ...... | | | | | |
| | 7770 | 17.000 | 21 | 19 | 45 38 49.8 | − 2 31.4 | +0.4 | ........ | 18.8 |
| | 7820 | 17.440 | 20 | 20 | | | | | |
| | 7850 | 10.405 | 20.5 | 20 | | | | | |
| | 7888 | 30.955 | 21.5 | 19 | 45 55 8.2 | −18 52.2 | +0.7 | ........ | 16.7 |
| | 7917 | 3.000 | 20 | 20.5 | | | | | |
| September 9, 1878.... | (4) | 28.877 | 19 | 16.5 | 45 47 3.0 | −10 46.4 | +1.6 | ........ | 18.2 |
| | 6372 | 22.105 | ...... | ...... | | | | | |
| | (3) | 19.510 | ...... | ...... | | | | | |
| | 6391 | 5.824 | ...... | ...... | | | | | |
| | 6390 | 3.260 | 19 | 17 | | | | | |
| | 6428 | 21.510 | 20 | 16 | 45 41 39.0 | − 5 20.0 | −0.7 | ........ | 18.3 |
| | (5) | 13.610 | 14 | 22 | | | | | |
| | 6522 | 22.300 | 20 | 16.5 | 45 42 4.5 | − 5 47.5 | −0.9 | ........ | 16.1 |
| | 6556 | 13.720 | 15 | 21 | | | | | |
| | 6599 | 17.370 | 16.5 | 20 | 45 32 6.5 | + 4 12.3 | −0.7 | ........ | 18.1 |
| | 6623 | 11.140 | 19 | 17.5 | | | | | |
| | (6) | 33.860 | 22 | 15 | 45 56 17.5 | −19 58.5 | −2.0 | ........ | 17.0 |
| | 6690 | 4.385 | ...... | ...... | | | | | |
| | 6691 | 4.148 | 12 | 24.5 | | | | | |
| | 6717 | 14.135 | 22 | 15 | 45 34 36.2 | + 1 44.1 | −2.2 | ........ | 18.1 |
| | 6718 | 16.705 | 12 | 25 | | | | | |
| | *6734 | 18.953 | 21.5 | 15.5 | 45 42 54.5 | − 6 34.8 | −1.8 | ........ | 17.9 |
| | 6769 | 14.205 | 13 | 24 | | | | | |
| | 6780 | 11.150 | 18 | 19 | 45 30 44.6 | + 5 34.3 | −0.7 | ........ | 18.2 |
| | 6784 | 12.465 | 18 | 19 | | | | | |
| | †6800 | 21.345 | ...... | ...... | | | | | |
| | 6806 | 29.980 | ...... | ...... | 45 24 25.2 | +11 56.1 | −1.8 | ........ | 19.5 |
| | 6813 | 29.725 | 20.5 | 16.5 | | | | | |
| | 6824 | 24.725 | ..... | ...... | | | | | |
| | ‡6856 | − 60.615 | 14 | 23 | | | | | |
| | 6881 | 29.795 | ...... | ...... | 45 41 15.0 | − 4 55.2 | −1.3 | ........ | 45 36 18.5 |
| | 6918 | 19.490 | 19 | 18 | | | | | |
| | 6959 | 2.005 | ...... | ...... | | | | | |
| | 6986 | 7.115 | 16.5 | 21 | | | | | |
| | 7022 | 12.500 | ...... | ...... | | | | | |

* Error of $5^{r}$ in this pair. † 6800 should read $26^{r}.345$. ‡ 6856 should read $-1^{r}+.615$.

*Observations and computations for latitude of The Dalles, Oreg.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. | | Half sum of declination. | Corrections. | | | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
| | | | N. | S. | | Micr. and refr. | Level. | Merid. | |
| | | | | | ° ′ ″ | ′ ″ | ″ | | ° ′ ″ |
| September 9, 1878.... | 7029 | 20.435 | 19 | 18.5 | 45 30 17.4 | + 6 3.1 | 0.0 | ........ | 45 36 20.5 |
| | 7060 | 11.470 | 18.5 | 19 | | | | | |
| | *[7064 | 13.470] | 19 | 18.5 | 45 36 20.0 | − 0 0.5 | −0.9 | ........ | 18.6 |
| | 7103 | 19.287 | 16 | 22 | | | | | |
| | 7105 | 19.300 | ...... | ...... | | | | | |
| | 7153 | 15.850 | 21 | 17 | 45 36 16.8 | + 0 4.2 | −2.2 | ........ | 18.8 |
| | 7167 | 16.050 | 14 | 24 | | | | | |
| | 7218 | 16.045 | ...... | ...... | | | | | |
| | 7332 | 8.590 | 19.5 | 20 | 45 32 50.0 | + 3 31.1 | −3.2 | ........ | 17.9 |
| | 7336 | 19.669 | ...... | ...... | | | | | |
| | 7337 | 19.790 | 15 | 23.5 | | | | | |
| | 7365 | 20.445 | ...... | ...... | | | | | |
| | 7373 | 18.880 | 20 | 18 | 45 43 0.6 | − 6 38.6 | −2.5 | ........ | 19.5 |
| | 7401 | 28.460 | 15 | 24 | | | | | |
| | 7453 | 18.355 | ...... | ...... | | | | | |
| | 7505 | 7.175 | 21.5 | 17 | 45 39 45.9 | − 3 24.9 | −2.9 | ........ | 18.1 |
| | †7530 | 24.670 | 13 | 25.5 | | | | | |
| | 7556 | 18.810 | ...... | ...... | | | | | |
| | (7) | 17.850 | ...... | ...... | | | | | |
| | 7614 | 6.905 | 19 | 20 | 45 43 44.6 | − 7 22.6 | −2.9 | ........ | 19.1 |
| | 7646 | 26.085 | 16 | 23 | | | | | |
| | 7676 | 9.580 | ...... | ...... | | | | | |
| | ...... | Lost .... | ...... | ...... | | | | | |
| | 7749 | 25.645 | 21 | 18 | 45 48 29.2 | −12 12.2 | −1.3 | ........ | 15.7 |
| | 7753 | 7.565 | 16.5 | 23 | | | | | |
| | 7770 | 17.330 | 20.5 | 18.5 | 45 38 50.4 | − 2 31.3 | −1.3 | ........ | 17.8 |
| | 7820 | 17.740 | 17 | 22.5 | | | | | |
| | 7850 | 10.680 | ...... | ...... | | | | | |
| | *a*7888 | 29.195 | 22 | 17 | 45 55 8.8 | −18 50.4 | −1.6 | ........ | 16.8 |
| | 7917 | 2.290 | 15 | 24.5 | | | | | |
| | 7995 | 11.330 | {21.5 | 18.5 | 45 40 29.9 | .......... | −0.2 | ........ | ........... |
| | *b*8028 | 31.145 | }18 | 22 | | | | | |
| | 8036 | 24.970 | 22 | 18 | | | | | |
| | 8059 | 21.330 | 19 | 21 | 45 44 15.3 | − 7 54.1 | 2.7 | ........ | 18.5 |
| | 8076 | 7.020 | 18 | 22 | | | | | |
| | 8082 | 26.150 | ...... | ...... | | | | | |
| | 8114 | 8.700 | ...... | ...... | | | | | |
| | 8125 | 21.693 | 19 | 21 | 45 42 33.4 | − 6 12.2 | −2.7 | ........ | 18.5 |
| | 8135 | 12.505 | ...... | ...... | | | | | |
| | 8153 | 16.920 | ...... | ...... | 45 35 45.8 | − 34.0 | (?) | ........ | (?) |
| | 8159 | 17.760 | ...... | ...... | | | | | |
| | 6335 | !19.490 | 24.5 | 12 | 45 47 50.0 | −11 34.4 | +0.7 | ........ | 16.3 |
| September 17, 1878... | 6357 | 2.345 | 13 | 23.5 | | | | | |
| | 6372 | 22.025 | ...... | ...... | 45 44 47.0 | − 8 32.5 | +0.7 | ........ | 15.2 |
| | (3) | 19.355 | ...... | ...... | | | | | |
| | 6391 | 5.655 | ...... | ...... | | | | | |
| | 6390 | 3.100 | ...... | ...... | | | | | |
| | 6427 | 8.085 | 18 | 19 | 45 49 47.2 | −13 34.5 | +3.4 | ........ | 16.1 |
| | 6463 | 28.195 | 23.5 | 13 | | | | | |
| | 6468 | 13.235 | 18 | 18.5 | 45 39 27.9 | − 3 10.2 | +1.6 | ........ | 19.3 |
| | 6477 | 10.770 | ...... | ...... | | | | | |
| | 6496 | 25.095 | 21 | 16 | | | | | |
| | 6522 | 20.020 | 19 | 18 | 45 42 5.4 | − 5 47.9 | +1.8 | ........ | 45 36 18.8 |
| | 6556 | 11.430 | 19.5 | 17 | | | | | |

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* I have omitted 7064; its result with 7103 will be 45° 36′ 22″.4. Perhaps the error is $0^{r}.1$, and the reading $13^{r}.570$. See September 6.

† 7530 should read $19^{r}.670$.

*a* Difference increased $1^{r}$. *b* Some great error in 8028; the reading should be about $11^{r}.92$.

*Discussion of latitude—Dalles.*

| Combination. | No. of obs. | No. of stars. | Latitude. | Cor. to micr. | Combination. | No. of obs. | No. of stars. | Latitude. | Cor. to micr. |
|---|---|---|---|---|---|---|---|---|---|
| | | | ° ′ ″ | ″ | | | | ° ′ ″ | ″ |
| 1 | 2 | 2 | 45 36 14.65 | +0.34 | 17 | 3 | 5 | 45 36 17.83 | +0.44 |
| 2 | 1 | 2 | 19.4 | —1.26 | 18 | 3 | 2 | 19.80 | —0.54 |
| 3 | 1 | 2 | 18.8 | +0.70 | 19 | 2 | 3 | 17.75 | —0.17 |
| 4 | 4 | 2 | 15.82 | +1.04 | 20 | 3 | 3 | 17.80 | 0.00 |
| 5 | 4 | 5 | 16.52 | +0.51 | 21 | 3 | 4 | 17.17 | —0.31 |
| 6 | 1 | 2 | 18.3 | +0.48 | 22 | 3 | 3 | 17.50 | +0.60 |
| 7 | 4 | 2 | 15.88 | +1.22 | 23 | 3 | 4 | 16.53 | +0.38 |
| 8 | 2 | 3 | 18.90 | +0.50 | 24 | 3 | 3 | 17.67 | +0.66 |
| 9 | 5 | 2 | 17.78 | +0.52 | 25 | 1 | 5 | 18.0 | —0.10 |
| 10 | 4 | 2 | 18.88 | +0.38 | 26 | 2 | 2 | 16.15 | +1.10 |
| 11 | 2 | 3 | 16.65 | +1.80 | 27 | 3 | 3 | 18.20 | +0.16 |
| 12 | 2 | 2 | 18.10 | —0.15 | 28 | 3 | 2 | 16.50 | +1.70 |
| 13 | 2 | 3 | 17.25 | +0.60 | 29 | 1 | 3 | 16.8 | +0.38 |
| 14 | 1 | 2 | 16.60 | +0.91 | 30 | 2 | 4 | 17.20 | +0.60 |
| 15 | 3 | 3 | 18.50 | —0.50 | 31 | 2 | 2 | 16.70 | +0.57 |
| 16 | 3 | 4 | 18.97 | —1.07 | 32 | 2 | 2 | 16.00 | +0.04 |

Final latitude, 45° 36′ 17″.78 ± 0″.09.

## ASTRONOMICAL STATION AT FRESNO, CAL., 1878.

### GEOGRAPHICAL POSITION.

Latitude 36° 43′ 31″.22.

Longitude ——.

Barometric altitude of observatory above sea-level (Lieutenant Ludlow's camp), 313.7 feet.

Discrepancies were found in the time observations at Fresno, which could not be cleared up owing to lack of time. The discussion of the longitude is therefore omitted in this place.

## ASTRONOMICAL STATION AT FRESNO, CAL., OCTOBER, 1878.

### GEOGRAPHICAL POSITION.

The location of the observatory was on a swell of ground some half mile south of the town. The pier was of cemented brick, as at the other stations. There was no lava-bed here as at The Dalles, nor bowlders as at Walla Walla, loaded with magnetic iron, to affect the needle, the soil being composed almost entirely of sand. It is seldom possible to get such a desirable spot, in all respects, for an observatory as was here presented. The view was unobstructed in all directions, bounded eastward at a great distance by Mounts Whipple, Goddard, and other great mountain masses of the Sierra Nevada, while westward lay the Coast Range.

### FRESNO AND ITS SURROUNDINGS.

Fresno is a town that owes its origin to the Southern Pacific Railroad. It is the capital of the county of that name, which is often designated in California as the county of colonies. The court-house is an expensive and showy building, and stands out in marked contrast with all other improvements, both public and private. At this season of the year there seemed to be no vegetation here—nothing green—except that produced by irrigation.

### METEOROLOGICAL CONDITIONS.

The pier and tent were in readiness for observations by October 1, and it was continuously clear till the 11th, when it rained, as also on the 13th and 14th. There was little or no wind, and no dust to interfere, notwithstanding the sandy soil.

### TELEGRAPHIC COMMUNICATIONS.

Ogden was got by way of San Francisco, and there being no delay in the use of the wires, longitudinal exchanges, with complete clock error, could have been had every night from October 4 to 11 had the conditions of the former place been equally favorable.

### METHOD OF OBSERVATION.

Same as at other stations.

### INSTRUMENTS.

Also the same.

### ADDENDA.

The elaborate stone pillars sent to Fresno for marking the meridian were placed, the one in the meridian north of the pier, just north of the railroad track and on a line with the first row of houses facing south; the other about the same distance southward, and near a road leading to one of the colonies.

*Mean place of stars for* 1878.0 *used for the determination of latitude of Fresno, Cal.*

| No. of pair. | No. B. A. C. | Class. | A. R. |  |  | Declination. |  |  |
|---|---|---|---|---|---|---|---|---|
|  |  |  | h. | m. | s. | ° | ′ | ″ |
|  | 6480 | A | 18 | 52 | 27 | 32 | 44 | 44.4 |
|  | 6491 | A | 18 | 54 | 23 | 32 | 31 | 23.8 |
|  | 6493 | C | 18 | 54 | 47 | 40 | 30 | 45.8 |
|  | 6674 | A A | 19 | 23 | 38 | 24 | 25 | 8.5 |
|  | 6717 | C | 19 | 30 | 20 | 48 | 59 | 50.8 |
|  | 6720 | C | 19 | 30 | 52 | 43 | 40 | 41.6 |
|  | 6728 | C | 19 | 32 | 39 | 43 | 26 | 1.6 |
|  | 6740 | A | 19 | 34 | 33 | 29 | 52 | 23.4 |
|  | 6784 | A | 19 | 41 | 48 | 33 | 26 | 40.7 |
|  | 6800 | C | 19 | 44 | 11 | 33 | 7 | 58.9 |
|  | 6817 | B | 19 | 46 | 26 | 40 | 17 | 24.3 |
|  | 6857 | B | 19 | 52 | 50 | 40 | 2 | 26.7 |
|  | (1) | C | 19 | 53 | 40 | 56 | 21 | 34.8 |
|  | 6868 | A | 19 | 54 | 33 | 17 | 11 | 3.6 |
|  | 6928 | A | 20 | 3 | 1 | 52 | 48 | 20.1 |
|  | 6933 | A | 20 | 4 | 34 | 20 | 33 | 13.0 |
|  | 6944 | A | 20 | 6 | 54 | 26 | 6 | 56.1 |
|  | 6983 | A | 20 | 11 | 42 | 47 | 20 | 24.4 |
|  | 7041 | B | 20 | 21 | 11 | 42 | 12 | 23.0 |
|  | 7100 | C | 20 | 28 | 37 | 42 | 46 | 35.2 |
|  | 7131 | A | 20 | 32 | 34 | 31 | 8 | 49.6 |
|  | 7132 | A | 20 | 32 | 35 | 31 | 5 | 51.5 |
|  | 7164 | A | 20 | 36 | 6 | 31 | 52 | 26.8 |
|  | 7174 | C | 20 | 37 | 32 | 41 | 16 | 50.4 |
|  | 7204 | A A | 20 | 41 | 16 | 33 | 30 | 50.9 |
|  | 7260 | B | 20 | 49 | 49 | 40 | 14 | 21.4 |
|  | 7313 | A | 20 | 57 | 40 | 39 | 1 | 42.8 |
|  | 7399 | B | 21 | 12 | 54 | 34 | 23 | 7.5 |
|  | 7411 | B | 21 | 15 | 17 | 48 | 59 | 41.7 |
|  | 7437 | A | 21 | 18 | 29 | 23 | 45 | 2.7 |
|  | 7461 | A | 21 | 22 | 18 | 27 | 4 | 41.0 |
|  | 7480 | A | 21 | 24 | 57 | 46 | 0 | 11.2 |
|  | 7520 | A | 21 | 32 | 3 | 18 | 46 | 13.5 |
|  | 7555 | C | 21 | 36 | 41 | 54 | 19 | 4.2 |
|  | 7571 | A | 21 | 39 | 7 | 25 | 5 | 5.6 |
|  | 7598 | A | 21 | 42 | 17 | 48 | 44 | 43.8 |
|  | 7627 | A A | 21 | 47 | 31 | 25 | 21 | 6.3 |
|  | (2) |  |  |  |  |  |  |  |
|  | 7676 | B | 21 | 57 | 22 | 52 | 17 | 40.2 |
|  | 7699 | B | 22 | 0 | 13 | 62 | 31 | 34.7 |
|  | 7707 | A | 22 | 1 | 18 | 62 | 11 | 26.4 |
|  | (4) |  |  |  |  |  |  |  |
|  | 7789 | B | 22 | 14 | 14 | 62 | 11 | 35.0 |
|  | 7796 | A | 22 | 15 | 31 | 11 | 35 | 27.7 |
|  | 7798 | A | 22 | 15 | 41 | 27 | 42 | 50.3 |
|  | 7800 | B | 22 | 15 | 59 | 45 | 55 | 20.8 |
|  | 7833 | (B) | 22 | 22 | 54 | [7]8 | 29 | 29.2 |
|  | 7837 | B | 22 | 23 | 10 | 64 | 30 | 37.3 |
|  | 7902 | A | 22 | 34 | 19 | 62 | 57 | 1.6 |
|  | 7908 | A A | 22 | 35 | 28 | 10 | 11 | 41.9 |
|  | 7967 | A | 22 | 45 | 20 | 65 | 33 | 31.5 |
|  | 7988 | (B) | 22 | 48 | 95 | [7]8 | 9 | 56.5 |
|  | 8034 | A A | 22 | 58 | 41 | 14 | 32 | 56.9 |
|  | 8054 | B | 23 | 1 | 28 | 58 | 45 | 38.1 |
|  | (5) | C | 23 | 4 | 39 | 16 | 56 | 2.5 |
|  | 8083 | A | 23 | 7 | 25 | 56 | 29 | 41.4 |
|  | 8138 | B | 23 | 15 | 15 | 61 | 32 | 42.4 |
|  | 8182 | A | 23 | 22 | 59 | 12 | 5 | 15.4 |
|  | 8206 | A | 23 | 27 | 54 | 30 | 39 | 7.1 |
|  | 8229 | A | 23 | 32 | 9 | 42 | 35 | 33.8 |
|  | (6) | C | 23 | 36 | 36 | [9]63 | 50 | 20.2 |
|  | 8250 | (B) | 23 | 37 | 10 | [7]9 | 39 | 15.0 |
|  | 8273 | A | 23 | 42 | 5 | 67 | 7 | 44.2 |
|  | 8331 | A A | 23 | 58 | 8 | [8]6 | 11 | 16.3 |
|  | 8344 | A | 23 | 55 | 24 | 60 | 32 | 36.1 |
|  | 8366 | B | 23 | 58 | 48 | 60 | 38 | 4.7 |
|  | 8370 | A | 23 | 59 | 26 | 12 | 43 | 2.2 |

---

[1] Sd. 1052.
[2] Gr. 3157.
[3] D. M. 20°. 5046.
[4] 54* Heis Pegasi.
[5] Sd. 1595.
[6] Gr. 4130.
[7] Position from Ay. 64 (preliminary).
[8] Position from mean of G. and B.
[9] See Fort Bayard, 9.

For 3 and 4 no accurate positions were available.

*Observations and computations for latitude, Fresno, Cal.*

| Date. | Number of star. | Micrometer readings. | Level. |  | Half sum of declination. | Corrections. |  |  | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | N. | S. |  | Micr. and refr. | Level. | Merid. |  |
|  |  |  |  |  | ° ′ ″ | ′ ″ | ″ |  | ° ′ ″ |
| October 3, 1878 ...... | 6674 | 8.720 | 26 | 8 | 36 42 48.2 | + 0 43.3 | +0.7 | ........ | 36 43 32.2 |
|  | 6717 | 7.650 | 9 | 25 |  |  |  |  |  |
|  | 6728 | 9.200 | 16.5 | 17.5 | 36 39 31.9 | + 3 58.3 | +1.4 | ........ | 31.6 |
|  | 6740 | 15.085 | 19.5 | 14.5 |  |  |  |  |  |
|  | *a*6784 | 8.110 | ...... | ...... | 36 52 22.7 | − 8 55.0 | +3.6 | ........ | 31.3 |
|  | 6800 | 16.985 | 19 | 15 | 36 35 33.4 | + 7 56.5 | +3.6 | ........ | 33.5 |
|  | 6817 | 16.320 | 20 | 14 |  |  |  |  |  |
|  | 6857 | 5.220 | ...... | ...... |  |  |  |  |  |
|  | 6928 | 8.018 | 18 | 16.5 | 36 41 7.8 | + 2 17.0 | +5.4 | ........ | 30.2 |
|  | 6933 | 11.400 | 24 | 10.5 |  |  |  |  |  |
|  | 6944 | 8.850 | 18.5 | 17 | 36 44 2.2 | − 0 33.6 | +3.8 | ........ | 32.4 |
|  | 6983 | 9.680 | 22 | 13 |  |  |  |  |  |
|  | 7164 | 14.848 | 14 | 21 | 36 35 2.6 | + 8 24.8 | +4.9 | ........ | 32.3 |
|  | 7174 | 2.385 | 28 | 7.5 |  |  |  |  |  |
|  | 7204 | 0.680 | 16 | 19 | 36 53 0.7 | − 9 32.7 | +2.5 | ........ | 30.5 |
|  | 7260 | 14.820 | 23 | 13 |  |  |  |  |  |
|  | 7313 | 4.475 | 19 | 17.5 | 36 42 50.9 | + 0 35.0 | +4.7 | ........ | 30.6 |
|  | 7399 | 5.340 | 24 | 12.5 |  |  |  |  |  |
|  | 7461 | 23.060 | 16 | 20.5 | 36 32 52.6 | +10 34.8 | +4.5 | ........ | 31.9 |
|  | 7480 | 7.385 | 27 | 10 |  |  |  |  |  |
|  | 7520 | 25.530 | 12 | 24.5 | 36 33 5.3 | +10 21.1 | +4.1 | ........ | 30.5 |
|  | 7555 | 10.195 | ...... | ...... |  |  |  |  |  |
|  | 7571 | 11.980 | *b*18 | 18 | 36 59 22.3 | −15 55.6 | −1.8 | ........ | [24.9] |
|  | 7598 | 29.645 | 16 | 21 |  |  |  |  |  |
|  | 7627 | 10.120 | ...... | ..... |  |  |  |  |  |
|  | ...... | 25.750 | *c*13 | 24 |  |  |  |  |  |
|  | 7676 | 4.500 | ...... | ...... |  |  |  |  |  |
| October 4, 1878 ...... | 6480 | 15.340 | 13 | 18 | 36 34 40.9 | + 8 46.3 | +5.0 | ........ | 32.2 |
|  | 6491 | 25.230 | 25 | 6 |  |  |  |  |  |
|  | 6493 | 7.290 | ...... | ...... |  |  |  |  |  |
|  | 6674 | 15.240 | 14 | 18.5 | 36 42 48.2 | + 0 42.5 | +2.9 | ........ | 33.6 |
|  | 6717 | 14.190 | 22.5 | 10 |  |  |  |  |  |
|  | 6728 | 12.535 | 17 | 16 | 36 39 31.9 | + 3 57.9 | +2.9 | ........ | 32.7 |
|  | 6740 | 18.410 | 20 | 13 |  |  |  |  |  |
|  | 6784 | 8.910 | ...... | ...... | 36 52 22.7 | − 8 56.4 | +2.9 | ........ | 29.2 |
|  | 6800 | 22.815 | 11 | 22 | 36 35 33.5 | + 7 55.3 | +2.9 | ........ | 31.7 |
|  | 6817 | 22.155 | *d*26 | 27 |  |  |  |  |  |
|  | *e*6857 | 6.080 | ...... | ...... |  |  |  |  |  |
|  | 7041 | 5.450 | ...... | ...... | 36 48 48.4 | − 5 17.0 | −0.4 | ........ | 31.0 |
|  | 7100 | 30.840 | 23 | 11 |  |  |  |  |  |
|  | *f*7131 | 11.430 | 10.5 | 23.5 |  |  |  |  |  |
|  | *f*7132 | 9.205 | ...... | ...... |  |  |  |  |  |
|  | 7164 | 20.725 | 18 | 16 | 36 35 2.7 | + 8 29.7 | −0.4 | ........ | 32.0 |
|  | 7174 | 8.140 | 16 | 19 |  |  |  |  |  |
|  | 7204 | 7.525 | 17 | 17 | 36 53 0.8 | − 9 33.7 | +0.5 | ........ | 27.6 |
|  | 7260 | 21.690 | 18 | 16.5 |  |  |  |  |  |
|  | 7313 | 7.535 | 20 | 15 | 36 42 51.0 | + 0 38.5 | +1.4 | ........ | 30.9 |
|  | 7399 | 8.485 | 17 | 18 |  |  |  |  |  |
|  | 7411 | *g*− 1.860 | 18.5 | 17 | 36 22 48.3 | +20 41.9 | −0.7 | ........ | 36 43 29.5 |
|  | 7437 | 29.525 | 16.5 | 19 |  |  |  |  |  |

*a* Paired thus, 6784, 6817, 6800, 6857.

*b* Some error in the level readings.

*c* Level reading incomplete.

*d* Level should be 26 N., 7 S.

*e* (6857) should read 11.080.

*f* The readings for 7131 and 7132 are questioned by the observer, but are correct.

*g* Reading, $-2^{r}.+0^{r}.860$.

*Observations and computations for latitude, Fresno, Cal.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. | | Half sum of declination. | Corrections. | | | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
| | | | N. | S. | | Micr. and refr. | Level. | Merid. | |
| | | | | | ° ′ ″ | ′ ″ | ″ | | ° ′ ″ |
| October 4, 1878 | 7461 | 22.920 | 16 | 19 | 36 32 52.7 | +10 39.3 | +1.4 | ........ | 36 43 33.4 |
| | 7480 | 7.135 | 21 | 14 | | | | | |
| | 7520 | − 2.603 | 11.5 | 24 | 36 33 5.4 | (*a*) | +2.7 | ........ | (*a*) |
| | 7555 | 24.290 | 28 | 8 | | | | | |
| | 7571 | 12.350 | ...... | ...... | 36 59 22.3 | −15 54.6 | +2.2 | ........ | 29.9 |
| | 7598 | 30.000 | 17 | 18 | | | | | |
| | 7627 | 0.508 | 21 | 14 | | | | | |
| | ...... | 26.535 | 12 | 24 | | | | | |
| | 7676 | 5.258 | 26 | 9 | | | | | |
| | 7699 | 27.285 | ...... | ...... | | | | | |
| | 7707 | 12.330 | 21.5 | 15 | | | | | |
| | ...... | 21.995 | 17 | 18.5 | | | | | |
| | 7798 | 13.385 | 15 | 21.5 | 36 49 39.6 | − 6 11.1 | +2.0 | ........ | 30.5 |
| | 7800 | 22.548 | 24 | 12 | | | | | |
| | 7833 | 22.375 | 13 | 24 | 36 30 58.0 | +12 26.0 | +4.7 | ........ | 28.7 |
| | 7837 | 3.955 | 30 | 6 | | | | | |
| | 7902 | 7.390 | 24 | 13 | 36 34 49.6 | + 8 40.2 | +1.8 | ........ | 31.6 |
| | 7908 | 20.235 | 15.5 | 21.5 | | | | | |
| | 7967 | 19.750 | 18 | 19 | 36 52 11.9 | − 8 43.1 | +1.4 | ........ | 30.2 |
| | 7988 | 6.835 | 21 | 16 | | | | | |
| | 8034 | 16.100 | 16.5 | 21 | 36 39 46.1 | + 3 46.4 | +1.8 | ........ | 34.3 |
| | 8054 | 10.510 | 23.5 | 14 | | | | | |
| | ...... | 14.450 | 16 | 21 | 36 43 20.8 | + 0 8.5 | +2.2 | ........ | 31.5 |
| | 8083 | 14.240 | 24 | 13 | | | | | |
| | 8138 | 2.195 | 18 | 19 | 36 49 27.5 | − 1 | +2.2 | ........ | ............ |
| | 8182 | 4.090 | 22 | 15 | | | | | |
| | 8206 | 18.698 | 16 | 21 | 36 37 49.8 | + 5 41.4 | +1.6 | ....... | 32.8 |
| | 8229 | 10.268 | 23.5 | 14 | | | | | |
| | ...... | 17.780 | 16 | 21 | 36 45 16.7 | − 1 46.3 | +0.7 | ........ | 31.1 |
| | 8250 | 15.155 | 22 | 15 | | | | | |
| | 8273 | 10.900 | 24 | 13.5 | 36 39 58.2 | + 3 31.2 | +2.0 | ....... | 31.4 |
| | 8331 | 16.115 | 16.5 | 21.5 | | | | | |
| | [b]8344 | 13.680 | ...... | ...... | 36 39 39.7 | + 3 50.5 | +1.7 | ........ | 31.9 |
| | 8366 | 16.745 | ...... | ...... | | | | | |
| | 8370 | 20.405 | ...... | ...... | | | | | |
| October 10, 1878 | 7902 | 7.990 | 23 | 16 | 36 34 50.6 | +8 45.1 | +2.9 | ........ | 38.6 |
| | 7908 | 20.955 | 20 | 19 | | | | | |
| | 7967 | 20.815 | 28.5 | 10.5 | 36 52 12.9 | −8 46.1 | +2.5 | ........ | 29.3 |
| | 7988 | 7.825 | 14 | 25 | | | | | |
| | 8034 | 16.355 | 21 | 18.5 | 36 39 47.2 | +3 45.0 | +0.5 | ........ | 32.7 |
| | 8054 | 10.800 | 19 | 20 | | | | | |
| | ...... | 13.388 | 18 | 21.5 | 36 43 22.0 | +0 8.4 | +0.7 | ........ | 31.1 |
| | 8083 | 13.180 | 22.5 | 17 | | | | | |
| | [c]8138 | 11.850 | 24 | 15 | 36 49 28.7 | −6 3.3 | +1.6 | ........ | 27.0 |
| | ...... | 14.880 | 16.5 | 23 | | | | | |
| | 8149 | 22.760 | ...... | ...... | 36 38 14.8 | +5 20.4 | +1.6 | ........ | 36.8 |
| | 8162 | 14.850 | 24 | 15 | | | | | |
| | 8182 | 2.880 | 18.5 | 21 | | | | | |
| | 8206 | 18.490 | 15.5 | 23.6 | 36 37 51.1 | +5 36.8 | +1.9 | ........ | 36 43 29.8 |
| | 8228 | 10.175 | 26.5 | 13 | | | | | |

[a] I cannot find what error has been made here.
[b] 8344 should read 12r.
[c] Paired thus, 8138, 8182; 8149, 8162. The fifth star I cannot identify with any well-known one.

*Observations and computations for latitude, Fresno, Cal.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. N. | Level. S. | Half sum of declination. | Corrections. Micr. and refr. | Corrections. Level. | Corrections. Merid. | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | ° ′ ″ | ′ ″ | ″ | | ° ′ ″ |
| October 10, 1878 ...... | ...... | 18.145 | ...... | ...... | 36 45 17.8 | −1 49.1 | +1.2 | ........ | 36 43 29.9 |
| | 8250 | 15.450 | ...... | ...... | | | | | |
| | 8273 | 12.165 | 31 | 8 | 36 39 59.3 | +3 30.4 | +1.4 | ........ | 31.1 |
| | 8331 | 17.360 | 10 | 29 | | | | | |
| | 8344 | 12.360 | 22 | 17 | 36 39 40.7 | +3 53.1 | −0.2 | ........ | 33.6 |
| | 8366 | 16.300 | 17 | 22.5 | | | | | |
| | 8370 | 20.130 | ...... | ...... | | | | | |
| October 12, 1878 ...... | 6674 | 15.483 | 16 | 21 | 36 42 48.4 | +0 42.2 | +1.4 | ........ | 32.0 |
| | 6717 | 14.440 | 23 | 14 | | | | | |
| | 6728 | 10.765 | 18 | 19.5 | 36 39 32.2 | +3 58.3 | +1.6 | ........ | 32.1 |
| | 6740 | 16.650 | 22 | 16 | | | | | |
| | *a*6784 | 10.242 | ...... | ...... | 36 52 23.1 | −8 50.9 | −0.9 | ........ | 31.3 |
| | 6800 | 24.100 | 18 | 19 | 36 35 33.9 | +7 58.9 | −0.9 | ........ | 31.9 |
| | 6817 | 23.350 | 18 | 19.5 | | | | | |
| | 6957 | 12.275 | ...... | ...... | | | | | |
| | 6928 | 12.430 | 24 | 14 | 36 41 8.4 | +2 24.1 | +1.6 | ........ | 34.1 |
| | 6933 | 15.988 | 16.5 | 22 | | | | | |
| | *b*6944 | 17.445 | ...... | ...... | 36 44 2.8 | −0 32.0 | +1.3 | ........ | 32.1 |
| | 6983 | 17.235 | ...... | ...... | | | | | |
| | (*) | 23.060 | ...... | ...... | | | | | |
| | 7041 | 4.980 | 21 | 17.5 | 36 48 49.1 | −5 19.8 | +2.0 | ........ | 31.3 |
| | 7100 | 30.330 | 20 | 18 | | | | | |
| | 7131 | 10.885 | ...... | ...... | | | | | |
| | 7132 | 8.630 | ...... | ...... | | | | | |
| | 7164 | 20.405 | ...... | ...... | 36 35 3.5 | +8 27.7 | +1.5 | ........ | 32.7 |
| | 7174 | 7.870 | ...... | ...... | | | | | |
| | 7204 | 6.593 | 15 | 23.5 | 36 53 1.7 | −9 32.9 | +2.2 | ........ | 31.0 |
| | 7260 | 20.738 | 26.5 | 12 | | | | | |
| | 7313 | 8.330 | 20 | 18.5 | 36 42 52.0 | + 39.8 | +0.5 | ........ | 32.3 |
| | 7399 | 9.312 | 19.5 | 19.5 | | | | | |
| | 7411 | *c*− 1.835 | ...... | ...... | 36 22 49.3 | +20 39.7 | +1.7 | ........ | 30.7 |
| | 7437 | 29.445 | ...... | ...... | | | | | |
| | 7461 | 22.715 | 15 | 24 | 36 32 53.8 | +10 35.2 | +2.7 | ........ | 31.7 |
| | 7480 | 7.030 | 27.5 | 11 | | | | | |
| | 7520 | 24.945 | 15 | 24 | 36 33 6.5 | +10 24.5 | +1.8 | ........ | 32.8 |
| | 7555 | 9.525 | 26 | 12 | | | | | |
| | 7571 | 11.200 | 16 | 23.5 | 36 59 23.5 | −15 54.5 | +1.4 | ........ | 30.4 |
| | 7598 | 28.820 | 16.5 | 13 | | | | | |
| | 7627 | *d*− 2.305 | ...... | ...... | | | | | |
| | ...... | 25.948 | 17 | 22.5 | | | | | |
| | 7676 | 4.655 | 25 | 14 | | | | | |
| | 7707 | 11.385 | 23.5 | 15.5 | | | | | |
| | ...... | 21.018 | 17 | 22 | | | | | |
| | 7789 | 22.313 | 21 | 19 | 36 54 0.1 | −10 34.6 | +2.7 | ........ | 28.2 |
| | 7796 | 6.645 | 22.5 | 17 | | | | | |
| | 7902 | 7.245 | 24.5 | 15.5 | 36 34 50.9 | + 8 41.4 | +0.5 | ........ | 32.8 |
| | 7908 | 20.120 | 16 | 23.5 | | | | | |
| | 7967 | 19.510 | 23.5 | 16.5 | 36 52 13.3 | − 8 44.1 | +0.4 | ........ | 29.6 |
| | 7988 | 6.570 | 17 | 23 | | | | | |
| | 8034 | 16.373 | 16 | 24.5 | 36 39 47.6 | + 3 42.9 | +0.7 | ........ | 36 43 31.2 |
| | 8054 | 10.870 | 25.5 | 15 | | | | | |

*a* Paired thus, 6784, 6817; 6800, 6857.

* This star may be Gr. 3157, 1$^r$ in error; omitted.

Read − 2$^r$ + .835.

*b* Difference of readings should be 0$^r$.790, not 0$^r$.210.

*d* Should read − 1$^r$ + .305.

*Observations and computations for latitude, Fresno, Cal.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. | | Half sum of declination. | Corrections. | | | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
| | | | N. | S. | | Micr. and refr. | Level. | Merid. | |
| | | | | | ° ′ ″ | ′ ″ | ″ | | ° ′ ″ |
| October 12, 1878 ..... | ...... | 14.132 | ...... | ...... | 36 43 22.4 | + 0 8.4 | +1.6 | ........ | 36 43 32.4 |
| | 8083 | 13.925 | ...... | ...... | | | | | |
| | 8138 | 12.198 | 24 | 16 | 36 49 29.0 | − 6 2.7 | +2.1 | ........ | 28.4 |
| | 8149 | 22.955 | 18 | 22.5 | 36 38 15.2 | + 5 14.5 | +2.1 | ........ | 31.8 |
| | 8162 | 15.190 | 25 | 15 | | | | | |
| | 8182 | 3.242 | 19 | 21 | | | | | |
| | 8206 | 18.992 | 17.5 | 23 | 36 37 51.5 | + 5 37.2 | +1.8 | ........ | 30.5 |
| | 8229 | 10.665 | 25.5 | 15 | | | | | |
| | ...... | 17.490 | ...... | ...... | 36 45 18.3 | − 1 48.7 | +2.6 | ........ | 32.2 |
| | 8250 | 14.805 | ...... | ...... | | | | | |
| | *a*8273 | 10.970 | 23 | 18 | 36 39 59.8 | + 3 27.0 | +3.6 | ........ | 30.4 |
| | 8331 | 17.080 | 23 | 18 | | | | | |
| | 8344 | 12.670 | 23.5 | 17 | 36 39 41.3 | + 3 48.0 | +3.6 | ........ | 32.9 |
| | 8366 | 16.745 | ...... | ...... | | | | | |
| | 8370 | 20.338 | ...... | ...... | | | | | |
| October 13, 1878 ..... | 6720 | 22.535 | ...... | ...... | 36 43 12.2 | + 0 19.2 | 0.0 | ........ | 31.4 |
| | 6728 | 11.635 | 23 | 16 | | | | | |
| | 6740 | 17.560 | 16 | 23 | | | | | |
| | *b*6784 | 10.130 | ...... | ...... | 36 52 23.1 | − 8 51.6 | −1.3 | ........ | 30.2 |
| | 6800 | 24.998 | 14 | 25 | 36 35 33.9 | + 7 59.6 | −1.3 | ........ | 32.2 |
| | 6817 | 24.255 | 23.5 | 16 | | | | | |
| | 6857 | 13.155 | ...... | ...... | | | | | |
| | ...... | 19.698 | ...... | ...... | 36 46 39.9 | − 3 9.7 | −0.3 | ........ | 29.9 |
| | 6868 | 15.015 | ...... | ...... | | | | | |
| | 6928 | 13.085 | 23 | 17 | 36 41 8.5 | + 2 23.5 | +0.5 | ........ | 32.5 |
| | 6933 | 16.628 | 15.5 | 24 | | | | | |
| | 6944 | 19.190 | 17 | 23 | 36 44 2.9 | − 0 28.8 | −0.5 | ........ | 33.6 |
| | 6983 | 19.900 | 22 | 17.5 | | | | | |
| | 7041 | 5.548 | ...... | ...... | | | | | |
| | 7100 | 30.940 | 21.5 | 19 | 36 48 49.2 | − 5 16.2 | −0.5 | ........ | 32.5 |
| | 7131 | 9.345 | 18 | 22 | | | | | |
| | 7132 | 11.530 | ...... | ...... | | | | | |
| | 7164 | 21.405 | ...... | ...... | 36 35 3.6 | + 8 29.1 | 0.0 | ........ | 32.7 |
| | 7174 | 8.835 | ...... | ...... | | | | | |
| | 7204 | 7.730 | 19 | 21 | 36 53 1.8 | − 9 32.9 | +0.5 | ........ | 29.4 |
| | 7260 | 21.875 | 22 | 18.5 | | | | | |
| | 7313 | 8.823 | 21.5 | 10.5 | 36 42 52.1 | + 0 38.4 | +0.2 | ........ | 30.7 |
| | 7399 | 9.772 | 19.5 | 21 | | | | | |
| | 7411 | *c*− .795 | 23 | 18 | 36 22 49.5 | +20 44.8 | −2.2 | ........ | 32.1 |
| | 7437 | 30.530 | 15 | 26 | | | | | |
| | 7461 | 24.393 | 17.5 | 23.5 | 36 32 54.0 | +10 36.4 | +0.7 | ........ | 31.1 |
| | 7480 | 8.680 | 24.5 | 16.5 | | | | | |
| | 7520 | 25.435 | 14 | 27.5 | 36 33 6.7 | +10 21.5 | +2.0 | ........ | 30.2 |
| | *d*7555 | 10.090 | 11 | 30 | | | | | |
| | 7571 | 12.165 | 17.5 | 24 | 36 50 23.6 | −15 54.9 | +2.3 | ........ | 36 43 31.0 |
| | 7598 | 29.810 | 27 | 14 | | | | | |
| | *e*7627 | − .300 | ...... | ...... | | | | | |
| | ...... | 27.455 | 14 | 28 | | | | | |
| | 7676 | 6.255 | 10 | 32 | | | | | |
| | 7699 | 26.468 | 26 | 16 | | | | | |
| | 7707 | 11.515 | 19.5 | 22.5 | | | | | |
| | ...... | 21.123 | ...... | ...... | | | | | |

*a* Difference $1^r$ too large. *b* 6784 should read $11^r.130$. *c* Reading − $1^r$ + 0.795.
*d* I assume that the level reading for 7555 = 30 N. 11 S. *e* 7627 should read $0^r.300$.

*Observations and computations for latitude, Fresno, Cal.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. |  | Half sum of declination. | Corrections. |  |  | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | N. | S. |  | Micr. and refr. | Level. | Merid. |  |
|  |  |  |  |  | ° ′ ″ | ′ ″ | ″ |  | ° ′ ″ |
| October 13, 1878 ...... | [a]7789 | 22.060 | 27 | 15 | 36 54 0.3 | −10 33.8 | +1.1 | ........ | 36 43 27.6 |
|  | 7796 | 7.410 | 17.5 | 26.5 |  |  |  |  |  |
|  | 7833 | 21.765 | ...... | ...... | 36 30 59.5 | +12 30.5 | +1.8 | ........ | 31.8 |
|  | 7837 | 3.233 | ...... | ...... |  |  |  |  |  |
|  | 7902 | 8.240 | 26.5 | 16.5 | 36 34 51.1 | + 8 37.2 | +1.8 | ........ | 30.1 |
|  | 7908 | 21.010 | 19 | 24 |  |  |  |  |  |
|  | 7967 | 20.390 | 26.5 | 16 | 36 52 13.4 | − 8 44.7 | +2.0 | ........ | 30.7 |
|  | 7988 | 7.435 | 19 | 24 |  |  |  |  |  |
|  | 8034 | 16.628 | 22 | 21 | 36 39 47.7 | + 3 39.4 | +2.5 | ........ | 29.6 |
|  | 8054 | 11.210 | 24.5 | 18.5 |  |  |  |  |  |
|  | ...... | 14.549 | 16.5 | 27 | 36 43 22.6 | + 5.9 | +1.6 | ........ | 36 43 30.1 |
|  | [b]8083 | 14.405 | 13 | 28 |  |  |  |  |  |

[a] Difference should be $15^{r}.65$.

[b] I have assumed that the level reading of 8083 was 28 N. 13 S.

*Discussion of latitude, Fresno.*

| Combination. | Number observations. | Number stars. | Latitude. | Corrected to micrometer. | Dates excluded. | Combination. | Number observations. | Number stars. | Latitude. | Corrected to micrometer. |
|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | ° ′ ″ | ″ |  |  |  |  | ° ′ ″ | ″ |
| 1........ | 1 | 3 | 36 43 32.2 | −0.79 | ........ | 16 ..... | 4 | 3 | (*) | ........ |
| 2........ | 3 | 2 | 32.60 | +0.06 | ........ | 17 ..... | 4 | 2 | (*) | ........ |
| 3........ | 4 | 3 | 31.95 | −0.21 | ........ | 18 ..... | 2 | 2 | 36 43 27.90 | +0.95 |
| 4a ...... | 4 | 2 | 30.50 | +0.80 | ........ | 19 ..... | 1 | 2 | 30.50 | +0.56 |
| 4b ...... | 4 | 2 | 32.32 | −0.71 | ........ | 20 ..... | 2 | 2 | 30.25 | −1.13 |
| 5........ | 1 | 2 | 29.9 | +0.28 | ........ | 21 ..... | 4 | 2 | 33.28 | −0.78 |
| 6 ........ | 3 | 2 | 32.27 | −0.21 | ........ | 22 ..... | 4 | 2 | 29.85 | +0.78 |
| 7........ | 3 | 2 | 32.70 | +0.05 | ........ | 23 ..... | 4 | 2 | 31.95 | −0.34 |
| 8....... | 3 | 4 | 31.60 | +0.48 | ........ | 24 ..... | 4 | 2 | 31.28 | −0.01 |
| 9 ....... | 4 | 2 | 32.42 | −0.76 | ........ | 25 ..... | 2 | 2 | 27.7 | +0.54 |
| 10....... | 4 | 2 | 29.62 | +0.86 | ........ | 26 ..... | 2 | 2 | 34.3 | −0.48 |
| 11....... | 4 | 2 | 31.12 | −0.05 | ........ | 27 ..... | 3 | 2 | 31.03 | −0.50 |
| 12....... | 3 | 2 | 30.77 | −1.86 | ........ | 28 ..... | 3 | 2 | 31.07 | +0.16 |
| 13........ | 4 | 2 | 32.02 | −0.96 | ........ | 29 ..... | 3 | 2 | 30.97 | −0.32 |
| 14........ | 3 | 2 | 31.17 | −0.94 | ........ | 30 ..... | 3 | 3 | 32.80 | −0.35 |
| 15........ | 3 | 3 | 30.43 | +1.43 | Oct. 3 |  |  |  |  |  |

Resulting latitude: 36° 43′ 31″.22±0″.15.

* Two stars, of which no accurate places can be found, belong to these combinations; hence there is no result from them till the stars are observed.

## ASTRONOMICAL STATION AT FORT BLISS (EL PASO), TEXAS.

### GEOGRAPHICAL POSITION OF STATION.

Longitude 106° 29′ 05″.37.

Latitude 31° 45′ 31″.14.

Barometric alt. of observatory above sea-level (top of monument, which is 3 feet high) 3,630.

The monument is situated in the public square of the village of El Paso, 25 feet northwest from its center, measured on a line parallel to the streets. The square is 250 feet on a side, and bounded on the southeast by Saint Louis street, on the northwest by Main and southwest and northeast by Oregon and Utah streets. The streets are 70 feet wide. The square is mostly built up on the southwest and southeast sides, has one house on the northwest side, and to the northeast is open to and forms part of the plain in its original wildness, thinly covered with mesquite, cactus and the like. The monument is of brick 18 by 20 inches, 28 inches above ground, on a brick foundation 3½ feet deep and 6 feet square at the base.

The village of El Paso (of which Franklin is an obsolete name) is situated on the north or left side of the Rio Grande, 1¼ miles from it at present, and opposite to the Mexican town of El Paso del Norte, and 2 miles from it. It does not contain over 300 inhabitants now. It was larger when it was an overland stage station in the early California emigration. It looks forward to a future in the Southern Pacific and the Chihuahua Railroads. The river flows closely to the Mexican town at present, but when the international boundary was located in its channel in 1851 it flowed only half a mile south of the Texan village, having shifted its bed since fully a mile southward, and in doing so destroyed valuable vineyards and the best part of the Mexican town.

The village is also, for the time being, designated Fort Bliss, because the troops assigned to that post are quartered in the village, while the post itself has no corporeal but only an official existence. Its first habitat was 2¼ miles northeast of the village on the river flat, but as the river encroached and threatened its destruction, another post was built half a mile eastward on a terrace or raised plain, a few feet above the river bottom. When subsequently the post was abandoned, the ground being private property, the buildings were left unguarded and are now mostly in ruins. On the re-establishment of the post a few years ago, the government rented quarters in the village until Congress should authorize the building of a new post, which it has done since the occupation of the station, and the new post will probably be west of the village.

Colonel Graham, United States Topographical Engineers, made the barometric altitude of Frontera 3,870 feet in 1851. Frontera (a ranch now in ruins) is some 15 miles up the river, and about 250 feet higher than El Paso, as determined by our aneroid barometer readings. This would make his altitude for El Paso 3,620 feet. The locally accepted altitude of the place is between 3,800 and 3,900 feet, which is probably a misappropriation of Colonel Graham's altitude for Frontera.

## PHYSICAL GEOGRAPHY DETAILS.

The Rio Grande here changes its course from the north, and by a semicircular sweep, 15 miles in diameter, it passes around the bold south end of the Franklin Ridge of Mountains until by a reverse curve it turns eastward at the old site of Fort Bliss. It passes through a longitudinal depression between the overlapping ends of the Franklin Mountains, east of the river, and the El Paso Mountains west of it, which extend from the conical Rodadero Peak near the boundary monument southward into Mexico. This depression is occupied by much eroded and decaying granite-like rock, which crops out in the river bed producing a rapid, and forms hills 200 to 600 feet high, increasing in height for 6 miles to the flank of the main Franklin Ridge. It is at the foot of the southeasternmost of these granite hills below the rapids, and due south of the Franklin Mountains, that the village of El Paso is situated.

The mountains on either side of the river are fringed by the remains of a mesa, about 360 feet above the river and apparently on the same level, and doubtless continuous across, before the granite hills were eroded or the country elevated to its present altitude, and before the many beautiful valleys for some 200 miles up the river, where the numerous ancient Indian as well as the later Spanish ruins are now all that remain, were drained and desiccated. That the elevation of the continental backbone, and the further desiccation of the whole Rio Grande Valley, is still in progress is indicated by recent lava outflows like that of the Mal Pais, by hot springs, and the less degree of desiccation existing only three hundred years ago when the Spaniards made settlements and had irrigating ditches where there is no water now within long distances.

The river is always yellow, with much impalpably fine sediment. It changes its bed often, even in a night, so that fording is always dangerous, and at places changes its course for several miles. Thus, had it not been for the Gadsden purchase the Mexican town of Mesilla would have become American, the river changing from east to west of that town and two miles beyond. At El Paso, where it is now the international boundary, it changed since 1850 a mile to the south. It is a vexed question where the boundary is, whether it remains fixed in the channel, as it was when the survey was made, or follows the changes. The question arises every time the customs officers of either country pursue smugglers. It also puts in question the ownership of large slices of valuable land as the changing river leaves it on one side or the other. Parties seem to claim the old channel or the new to be the boundary whichever is to their advantage.

### METEOROLOGICAL CONDITIONS.

The rainfall is deficient, and cultivation is possible only as far away from the river as the irrigating ditches can be carried. The traditional rainy season is usually expected during June and July, but according to the experience of present residents, during the last few years the heaviest rains have occurred during July, August, and September, particularly the last two months. During my occupancy of this station, beginning August 6, 1878, there was an almost uninterrupted state of atmospheric disturbance, being cloudy all the time, often overcast, with occasional rains, and a few heavy rainfalls and high winds until September 11, when there was a sudden and remarkable change to a perfectly clear sky, light winds and serene weather, which lasted until my departure, on September 18, except a few cirro-cumuli clouds on the 17th. During the period of bad weather, hardly a day passed without a heavy storm somewhere between El Paso and Pueblo, Colorado, in the Rio Grande Valley, or along the mountains east of it, and telegraphic connection with Ogden for longitude work was prevented for a whole month.

Rain fell on August 10, 12, 16, 19, 22, 23, 28, and 29, and September 4, 6, and 10. On August 28, there was a so-called cloud-burst, and about two inches of rain fell in two hours, flooding the streets with a roaring torrent. During the period of clouds and light rains the wind blew exclusively from the eastern quarters from 2 to 12 miles an hour, with daily intervals of calm. On August 26, the wind shifted to the western quarters, blew 25 miles an hour, and again 20 on the 28th, when the cloud-burst happened. After this the wind blew mostly from the eastern quarters again until September 11, with occasional velocities from 10 to 23 miles an hour, with calms on but three or four days. From September 11 the weather was clear and settled, with light winds from east and west with frequent calms. On eight days there were thunder gusts and heat-lightning with easterly winds. The heavy rains came with westerly winds. In the case of both the thunder-storms from northeast and the heavy rains from the southwest, the clearing winds veered from those quarters towards the right.

The night minimum temperatures until September 10 ranged from 69° to 76°, the day maximum temperatures from 80° to 95°; after September 10, 58° to 64° and 76° to 86° respectively.

The hourly barometric readings from August 10 to 30 afford the following horary curve:

| Hours. | Correction to barometer reading. | Hours. | Correction to barometer reading. |
|---|---|---|---|
| 7 a. m | — 0.041 | 7 p. m | + 0.039 |
| 8 " | — 0.046 | 8 " | + 0.018 |
| 9 " | — 0.044 | 9 " | — 0.006 |
| 10 " | — 0.042 | 10 " | — 0.015 |
| 11 " | — 0.025 | 11 " | — 0.016 |
| 12 m | — 0.004 | 12 " | — 0.018 |
| 1 p. m | + 0.013 | 1 a. m | — 0.015 |
| 2 " | + 0.034 | 2 " | — 0.014 |
| 3 " | + 0.048 | 3 " | — 0.007 |
| 4 " | + 0.066 | 4 " | — 0.013 |
| 5 " | + 0.071 | 5 " | — 0.021 |
| 6 " | + 0.061 | 6 " | — 0.033 |

### PERSONNEL.—OBSERVATORY.—TELEGRAPH LINES.

The astronomical observer was Miles Rock, C. E., civilian assistant engineer, and the meteorological observer and assistant, Fred. W. Floyd, E. M.; S. W. McMaster was temporarily employed to assist in the hourly meteorological readings, and proved very capable.

The observatory was a wall tent, 9 feet square, with the middle seam of the roof ripped, and fastened apart for a meridian opening.

The United States Military Telegraph and the Western Union lines were used; the former from El Paso to Santa Fé, in the circuit *via* Denver, and from El Paso to Mesilla; thence to San Diego in the circuit *via* California; the latter from Santa Fé and San Diego respectively to Ogden, Utah.

### DESCRIPTION OF INSTRUMENTS USED.

The instruments were the same as those used at the Fort Bayard station, and for details see the accompanying report on that station. The transit was by Würdemann, No. 28; Hutton mean time chronometer, No. 288; and Negus break-circuit sidereal chronometer, No. 1344. All the observations were made by the eye and ear method. The mean-time chronometer was carried to the telegraph office for exchange of signals, a distance of 725 feet.

POINTS WITH WHICH CONNECTIONS WERE MADE, ETC.

Robert Reeder, of the United States Signal Corps, was the telegraph operator. Two circuits were used in making connection with the United States Engineer Observatory at Ogden, Utah. The first, *via* San Diego, Cal., was used on September 7, 8, and 10; El Paso to Mesilla, 50 miles; thence to Fort Bayard, 100, and beyond identically the same as in the signals from Fort Bayard. The total length of the circuit was about 2,300 miles. The other circuit *via* Santa Fé, N. Mex., was made on September 11 and 12; from El Paso to Mesilla, 50 miles, and thence the same as in the signals from Fort Bayard station. The total length of the circuit was about 1,400 miles.

On some evenings there was much trouble to effect communication, owing to length of line, bad weather, and other causes, but finally the success was complete.

The battery power used, as far as I could learn, was as follows: El Paso, 7 cells; Mesilla, 14 cells. This is not a relay station, but El Paso is connected with the San Diego or Santa Fé line as required by a switch; Santa Fé, 70 cells; Silver City, 50 cells.

The observations at Fort Bliss have been computed and arranged as follows, by Prof. T. H. Safford:

*Tabulation of stars used for determination of time at Ogden, Utah, and Fort Bliss, Texas.*

| Name of star. | Ogden. | | | | | Fort Bliss. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | September 7. | September 8. | September 10. | September 11. | September 12. | September 7. | September 8. | September 10. | September 11. | September 12. |
| ξ Herculis | ...... | ...... | ...... | × | ...... | ...... | ...... | ...... | ...... | ...... |
| o Herculis | ...... | ...... | ...... | × | × | ...... | ...... | ...... | ...... | ...... |
| A Herculis | ...... | ...... | ...... | × | × | ...... | ...... | ...... | ...... | ...... |
| κ Lyræ | × | ...... | ...... | × | ...... | ...... | ...... | ...... | ...... | ...... |
| 109 Herculis | × | × | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| χ Draconis | × | | × | × | × | ...... | ...... | ...... | ...... | ...... |
| 9 Heis Lyræ | × | | × | ...... | × | ...... | ...... | ...... | ...... | ...... |
| 11 Heis Lyræ | × | × | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| Groom. 2655 | × | × | ...... | × | × | ...... | ...... | ...... | ...... | ...... |
| 110 Herculis | ...... | × | × | ...... | × | ...... | ...... | ...... | ...... | ...... |
| β Lyræ | ...... | ...... | × | × | ...... | ...... | ...... | ...... | ...... | ...... |
| δ¹ Lyræ | ...... | ...... | ...... | × | ...... | ...... | ...... | ...... | ...... | ...... |
| 50 Draconis | × | ...... | × | ...... | × | ...... | ...... | ...... | ...... | ...... |
| γ Lyræ | ...... | ...... | × | × | ...... | ...... | ...... | ...... | ...... | ...... |
| ζ Aquilæ | × | × | ...... | × | × | ...... | ...... | ...... | ...... | ...... |
| ι Lyræ | × | × | ...... | ...... | × | ...... | ...... | ...... | ...... | ...... |
| 19 Lyræ | × | × | ...... | ...... | × | ...... | ...... | ...... | ...... | ...... |
| θ Lyræ | × | ...... | ...... | ...... | × | ...... | ...... | ...... | ...... | ...... |
| δ Draconis | ...... | × | ...... | × | ...... | ...... | ...... | ...... | ...... | ...... |
| τ Draconis | × | × | × | ...... | × | ...... | ...... | ...... | ...... | ...... |
| 4 Cygni | ...... | × | × | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| β Cygni | ...... | ...... | × | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 9 Cygni | ...... | ...... | × | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| φ Cygni | ...... | ...... | × | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| δ Cygni | ...... | ...... | ...... | ...... | ...... | × | ...... | ...... | ...... | ...... |
| ε Draconis | ...... | ...... | × | ...... | ...... | × | ...... | ...... | ...... | ...... |
| γ Sagittæ | ...... | ...... | ...... | ...... | ...... | × | ...... | ...... | ...... | ...... |
| τ Aquilæ | ...... | ...... | ...... | ...... | ...... | × | ...... | ...... | ...... | ...... |
| θ Aquilæ | ...... | ...... | ...... | ...... | ...... | × | ...... | ...... | ...... | ...... |
| γ Cygni | ...... | ...... | ...... | ...... | ...... | × | × | × | ...... | ...... |
| π Capricorni | ...... | ...... | ...... | ...... | ...... | × | ...... | ...... | ...... | ...... |
| ε Delphini | ...... | ...... | ...... | ...... | ...... | × | × | × | ...... | ...... |
| Groombr. 3241 | ...... | ...... | ...... | ...... | ...... | ...... | × | × | ...... | × |
| α Delphini | ...... | ...... | ...... | ...... | ...... | ...... | × | × | × | × |
| α Cygni | ...... | ...... | ...... | ...... | ...... | ...... | × | × | × | × |
| ε Cygni | ...... | ...... | ...... | ...... | ...... | ...... | × | × | × | × |
| μ Aquarii | ...... | ...... | ...... | ...... | ...... | ...... | × | × | × | × |
| ν Cygni | ...... | ...... | ...... | ...... | ...... | ...... | × | ...... | ...... | ...... |
| Br. 2749 | ...... | ...... | ...... | ...... | ...... | ...... | × | × | × | × |
| ς² Ursæ Majoris, S. P | ...... | ...... | ...... | ...... | ...... | ...... | × | ...... | ...... | ...... |
| 61 Cygni | ...... | ...... | ...... | ...... | ...... | ...... | ...... | × | × | × |
| ζ Cygni | ...... | ...... | ...... | ...... | ...... | ...... | × | × | ...... | × |
| Br. 2777 | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | × | ...... |
| τ Cygni | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | × | × |
| 11 Cephei | ...... | × | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 16 Pegasi | ...... | × | ...... | × | × | ...... | ...... | ...... | ...... | ...... |
| 17 Pegasi | ...... | × | ...... | × | × | ...... | ...... | ...... | ...... | ...... |
| 20 Pegasi | ...... | × | ...... | × | × | ...... | ...... | ...... | ...... | ...... |

*Tabulation of stars used for determination of time, &c.*—**Continued.**

| Name of star. | Ogden. | | | | | Fort Bliss. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | September 7. | September 8. | September 10. | September 11. | September 12. | September 7. | September 8. | September 10. | September 11. | September 12. |
| α Aquarii | | | | | | | | | × | |
| ι Pegasi | | | × | | | | | | | |
| 27 Pegasi | | × | | × | × | | | | | |
| π Pegasi | | | | | | | | | × | |
| 24 Cephei | | × | × | × | × | | | | × | |
| θ Aquarii | | | | | | | × | × | × | |
| γ Aquarii | | | | | | | × | × | × | |
| 31 Pegasi | | | × | | × | | | | | |
| π Aquarii | | | | | | | × | × | × | |
| P. xxii. 113 | | | | | × | | | | | |
| 38 Pegasi | | × | × | | × | | | | | |
| 9 H. Draconis, S. P | | | | | | | × | × | × | × |
| 39 Pegasi | × | | | | | | | | | |
| 7 Lacertæ | | | | | | | | × | × | × |
| Groom. 3804 | | × | | | | | | | | |
| 226 Cephei B | | | | | | | × | × | × | × |
| 31 Cephei | × | × | | × | × | | | | | |
| 10 Lacertæ | | | | | | | | | × | × |
| ξ Pegasi | | | | | | | × | | × | |
| η Pegasi | × | × | × | × | | | | | | |
| λ Pegasi | × | × | | × | × | | × | × | | × |
| ι Cephei | × | | × | × | × | | × | | | × |
| λ Aquarii | | | | | | | | × | | |
| Br. 1508, S. P | | | | | | | × | | | × |
| ο Andromedæ | | | | | | | × | | | × |
| β Pegasi | | | × | | | | | | | |
| α Pegasi | | | | | | | × | | | × |
| π Cephei | × | | × | | | | | | | |
| 130 Heis Pegasi | × | | | | | | | | | |
| ο Cephei | × | | | | | × | | × | × | |
| τ Pegasi | | | | | | × | | | | |
| υ Pegasi | × | | | | | | | | | |
| λ Piscium | | | | | | | | × | × | |
| 70 Pegasi | × | | | | | | | | | |
| 72 Pegasi | × | | | | | | | | | |
| λ Andromedæ | | | | | | × | | | | |
| ι Piscium | | | | | | × | | | × | |
| Groombr. 4163 | | | | | | × | | | | |
| ω Piscium | | | | | | × | | | × | × |
| α Andromedæ | | | | | | × | | | | |
| γ Pegasi | | | | | | × | | | | |
| Cassiopeiæ | | | | | | | | | | × |
| δ Piscium | | | | | | | | | | × |
| 32 H. Camelopard., S. P | | | | | | | | | | × |
| ε Piscium | | | | | | | | | | × |

*Fort Bliss, September 7, 1878; before signals.*

| Name of star. | Clamp. | T. | | | Bb. | Aa. | Cc. | T'. | | | A. R. | | | ΔT. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | | *s.* |
| δ Cygni | E. | 19 | 42 | 36.63 | + 0.13 | − 0.15 | + 0.28 | 19 | 42 | 36.89 | 19 | 41 | 12.50 | − 1 | 24.39 |
| ε Draconis | E. | | 50 | 0.33 | + 0.22 | − 0.83 | + 0.58 | | 50 | 0.30 | | 48 | 36.49 | 1 | 23.81 |
| γ Sagittæ | E. | | 54 | 46.58 | − 0.03 | + 0.11 | + 0.21 | | 54 | 46.87 | | 53 | 23.28 | (1 | 23.59) |
| τ Aquilæ | E. | 19 | 59 | 38.40 | − 0.03 | + 0.20 | + 0.20 | 19 | 59 | 38.77 | 19 | 58 | 14.49 | 1 | 24.28 |
| θ Aquilæ | E. | 20 | 6 | 27.99 | − 0.03 | + 0.25 | + 0.20 | 30 | 6 | 28.41 | 20 | 5 | 4.43 | 1 | 23.98 |
| γ Cygni | W. | | 19 | 18.82 | − 0.06 | − 0.08 | − 0.26 | | 19 | 18.42 | | 17 | 54.13 | 1 | 24.29 |
| π Capricorni | W. | | 21 | 48.50 | − 0.03 | + 0.38 | − 0.21 | | 21 | 48.64 | | 20 | 24.63 | 1 | 24.01 |
| ε Delphini | W. | 20 | 28 | 50.92 | − 0.05 | + 0.17 | − 0.20 | 20 | 28 | 50.84 | 20 | 27 | 26.75 | − 1 | 24.09 |

NORMAL EQUATIONS.

$a_0 = +0^s.60 \qquad c_0 = +0^s.25 \qquad \Delta T_0 = -1^m\ 24^s.16$ for $20^h.0$

$$\begin{aligned}
&\quad\ \ ^{s.}\\
0 &= +0.076 + 5.66\,d\Delta T + 1.09\,da + 1.51\,dc\\
0 &= +0.195 + 1.09\,d\Delta T + 2.54\,da - 2.42\,dc\\
0 &= +0.132 + 1.51\,d\Delta T - 2.42\,da + 9.74\,dc
\end{aligned}$$

$$\begin{aligned}
&\qquad\ ^{s.} & &\qquad\quad ^{m.}\quad ^{s.}\\
d\Delta T &= +0.027 & \Delta T &= -1\ \ 24.183\ (\text{wt.} = 4.33)\\
da &= -0.138 & a &= +\ \ \ 0.462\ (\text{wt.} = 1.54)\\
dc &= -0.052 & c &= +\ \ \ 0.198\ (\text{wt.} = 6.18)
\end{aligned}$$

### *Fort Bliss, September 7, 1878, after signals.*

| Name of star. | Clamp. | T. | | | Bb. | Aa. | Cc. | T'. | | | A.R. | | | Δ T. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| ο Cephei | W. | 23 | 15 | 7.99 | − 0.16 | − 0.95 | − 0.55 | 23 | 15 | 6.33 | 23 | 13 | 41.76 | − 1 | 24.57 |
| τ Pegas. | W. | | 16 | 4.32 | − 0.08 | + 0.10 | − 0.23 | | 16 | 4.11 | | 14 | 39.98 | 1 | 24.13 |
| λ Andromedæ | W. | | 33 | 5.05 | − 0.10 | − 0.22 | − 0.30 | | 33 | 4.43 | | 31 | 39.95 | 1 | 24.48 |
| ι Piscium | W. | | 35 | 9.11 | − 0.07 | + 0.28 | − 0.21 | | 35 | 9.11 | | 33 | 44.67 | 1 | 24.44 |
| Groombr. 4163 | E. | | 50 | 25.67 | − 0.19 | − 1.49 | + 0.75 | | 50 | 24.74 | | 49 | 0.33 | 1 | 24.41 |
| ω Piscium | E. | 23 | 54 | 31.11 | − 0.06 | + 0.27 | + 0.21 | 23 | 54 | 31.53 | 23 | 53 | 6.91 | 1 | 24.62 |
| ε Andromedæ | E. | 0 | 3 | 33.06 | − 0.08 | + 0.04 | + 0.24 | 0 | 3 | 33.26 | 0 | 2 | 9.09 | 1 | 24.17 |
| γ Pegasi | E. | 0 | 8 | 25.58 | − 0.07 | + 0.19 | + 0.22 | 0 | 8 | 25.92 | 0 | 7 | 1.34 | − 1 | 24.58 |

NORMAL EQUATIONS.

$$a_0 = +0^s.60 \qquad c_0 = +0^s.25 \qquad \Delta T_0 = -1^m.24^s.44 \qquad \text{for } 23^h.7$$

$$\begin{aligned} 0 &= -\overset{s}{0.050} + 5.71\, d\,\Delta T - 0.19\, d\,a + 0.38\, d\,c \\ 0 &= -0.078 - 0.19\, d\,\Delta T + 2.89\, d\,a - 0.27\, d\,c \\ 0 &= +0.490 + 0.38\, d\,\Delta T - 0.27\, d\,a + 12.19\, d\,c \end{aligned}$$

$$\begin{aligned} d\,\Delta T &= +\overset{s.}{0.012} & \Delta T &= -\overset{m.}{1}\ \overset{s}{24.428}\ (\text{wt.} = 5.69) \\ d\,a &= +0.024 & a &= +\ 0.624\ (\text{wt.} = 2.88) \\ d\,c &= -0.040 & c &= +\ 0.210\ (\text{wt.} = 12.14) \end{aligned}$$

*Fort Bliss, September* 8, 1878; *before signals.*

| Name of star. | Clamp. | T. | | | B*b*. | A*a*. | C*c*. | T′. | | | A. R. | | | Δ T. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| γ Cygni | E. | 20 | 19 | 18.66 | 0.00 | − 0.07 | + 0.22 | 20 | 19 | 18.81 | 20 | 17 | 54.12 | − 1 | 24.69 |
| ε Delphini | E. | | 28 | 51.21 | 0.00 | + 0.14 | + 0.17 | | 28 | 51.52 | 20 | 27 | 26.74 | | 24.78 |
| Groombr. 3241 S. P. | E. | | 31 | 59.23 | + 0.01 | − 0.81 | + 0.56 | | 31 | 58.99 | 20 | 30 | 33.66 | | 25.33 |
| α Delphini | E. | | 35 | 26.24 | 0.00 | + 0.12 | + 0.18 | | 35 | 26.54 | 20 | 34 | 1.90 | | 24.64 |
| α Cygni | E. | | 38 | 44.26 | 0.00 | − 0.12 | + 0.24 | | 38 | 44.38 | 20 | 37 | 19.53 | | 24.85 |
| ε Cygni | W. | | 42 | 45.08 | + 0.04 | − 0.01 | − 0.21 | | 42 | 44.90 | 20 | 41 | 19.88 | | 25.02 |
| μ Aquarii | W. | | 47 | 33.42 | + 0.03 | + 0.26 | − 0.17 | | 47 | 33.54 | 20 | 46 | 8.57 | | 24.97 |
| ν Cygni | W. | | 54 | 5.99 | + 0.14 | − 0.08 | − 0.23 | | 54 | 5.82 | 20 | 52 | 40.81 | | 25.01 |
| Bradl. 2749 | W. | 20 | 54 | 33.54 | − 0.03 | − 1.66 | − 0.99 | 20 | 54 | 30.86 | 20 | 53 | 6.23 | | 24.63 |
| σ² Ursæ Maj. S. P. | W. | 21 | 1 | 4.91 | − 0.01 | + 0.99 | + 0.45 | 21 | 1 | 6.34 | 20 | 59 | 41.19 | | 25.15 |
| ζ Cygni | W. | 21 | 9 | 13.09 | + 0.04 | + 0.02 | − 0.20 | 21 | 9 | 12.95 | 21 | 7 | 48.18 | − 1 | 24.77 |

NORMAL EQUATIONS.

$a_0 = +0^s.50 \qquad c_0 = +0^s.15 \qquad \Delta T_0 = -1^m\ 24^s.84 \quad \text{for } 20^h.7$

$$
\begin{aligned}
0 &= +\overset{s.}{0.281} + 7.98\, d\,\Delta T + 0.54\, d\,a + 1.25\, d\,c \\
0 &= +0.701 + 0.54\, d\,\Delta T + 6.21\, d\,a + 2.20\, d\,c \\
0 &= +0.091 + 1.25\, d\,\Delta T + 2.20\, d\,a + 18.86\, d\,c
\end{aligned}
$$

$$
\begin{aligned}
d\,\Delta T &= -\overset{s.}{0.030} & \Delta T &= -\overset{m.}{1}\ \overset{s.}{24.870}\ (\text{wt.} = 7.87) \\
d\,a &= -0.118 & a &= +\ 0.382\ (\text{wt.} = 5.93) \\
d\,c &= +0.021 & c &= +\ 0.171\ (\text{wt.} = 17.13)
\end{aligned}
$$

*Fort Bliss, September 8, 1878; after signals.*

| Name of star. | Clamp. | T. | | | Bb. | Δa. | Oc. | T'. | | | A R. | | | ΔT. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | h. | m. | s. | s. | s. | s. | h. | m. | s. | h. | m. | s. | m. | s. |
| θ Aquarii | W. | 22 | 11 | 52.95 | − 0.05 | + 0.09 | − 0.15 | 22 | 11 | 52.84 | 22 | 10 | 28.05 | − 1 | 24.70 |
| γ Aquarii | W. | | 16 | 50.47 | − 0.05 | + 0.08 | − 0.15 | | 16 | 50.35 | 22 | 15 | 25.46 | 1 | 24.89 |
| π Aquarii | W. | | 20 | 31.90 | − 0.05 | + 0.07 | − 0.15 | | 20 | 31.77 | 22 | 19 | 06.95 | 1 | 24.82 |
| 9 H. Draconis S. P | W. | | 26 | 06.12 | + 0.08 | + 0.55 | + 0.64 | | 26 | 07.39 | 22 | 24 | 42.11 | 1 | 25.28 |
| 226 Cephei B | W. | | 31 | 38.54 | − 0.18 | − 0.38 | − 0.61 | | 31 | 37.37 | 22 | 30 | 11.98 | 1 | 25.39 |
| ζ Pegasi | W. | | 36 | 51.62 | − 0.06 | + 0.05 | − 0.15 | | 36 | 51.46 | 22 | 35 | 26.71 | 1 | 24.75 |
| λ Pegasi | E. | | 42 | 08.04 | − 0.10 | + 0.02 | + 0.16 | | 42 | 08.12 | 22 | 40 | 43.29 | 1 | 24.83 |
| ι Cephei | E. | | 46 | 49.64 | − 0.19 | − 0.18 | + 0.36 | | 46 | 49.63 | 22 | 45 | 24.56 | 1 | 25.07 |
| Bradl. 1508, S. P | E. | | 51 | 34.39 | + 0.16 | + 0.64 | − 0.75 | | 51 | 34.44 | 22 | 50 | 09.07 | 1 | 25.37 |
| o Andromedæ | E. | 22 | 57 | 47.50 | − 0.12 | − 0.03 | + 0.20 | 22 | 57 | 47.64 | 22 | 56 | 22.55 | 1 | 25.09 |
| α Pegasi | E. | 23 | 00 | 09.73 | − 0.09 | + 0.04 | + 0.16 | 23 | 00 | 09.84 | 22 | 58 | 45.10 | − 1 | 24.74 |

NORMAL EQUATIONS.

$a_0 = +0^s.20 \qquad c_0 = +0^s.15 \qquad \Delta T_0 = -1^m\ 24^s.90 \quad \text{for } 22^h.6$

$$
\begin{aligned}
&\phantom{0=+}\text{s.}\\
0 &= +0.067 + 7.51\, d\,\Delta T + 2.49\, da - 0.19\, dc\\
0 &= +0.625 + 2.49\, d\,\Delta T + 10.46\, da - 0.38\, dc\\
0 &= -0.036 - 0.19\, d\,\Delta T - 0.38\, da + 21\ 26\, dc
\end{aligned}
$$

$$
\begin{aligned}
&\text{s.} && \text{m.}\quad \text{s.}\\
d\Delta T &= +0.012 & \Delta T &= -1\quad 24.888\ (\text{wt.} = 6.92)\\
da &= -0\ 063 & a &= +\qquad 0.137\ (\text{wt.} = 9.63)\\
dc &= +0.001 & c &= +\qquad 0.151\ (\text{wt.} = 21.26)
\end{aligned}
$$

*Fort Bliss, September 10, 1878; before signals.*

| Name of star. | Clamp. | T. | B*b*. | A*a*. | C*c*. | T′. | AR. | ΔT. |
|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *h. m. s.* | *m. s.* |
| γ Cygni | ........ | 20 19 21.08 | − 0.27 | − 0.20 | − 0 07 | 20 19 20.54 | 20 17 54.08 | − 1 26.46 |
| ε Delphini | ........ | 28 52.85 | − 0.20 | + 0.40 | − 0.05 | 28 53.00 | 20 27 26.72 | 1 26.28 |
| Groombr. 3241 | ........ | 32 03.18 | − 0.51 | − 2.34 | − 0.17 | 32 00.16 | 20 30 33.56 | 1 26.60 |
| μ Delphini | ........ | 35 28.22 | − 0.21 | + 0.32 | − 0.05 | 35 28.28 | 20 34 01.88 | 1 26.40 |
| ε Cygni | ........ | 38 46.82 | − 0.28 | − 0.36 | − 0.07 | 38 46.11 | 20 37 19.49 | 1 26.62 |
| α Cygni | ........ | 42 46.84 | − 0.28 | − 0.04 | + 0.06 | 42 46.58 | 20 41 19.86 | 1 26.72 |
| α Aquarii | ........ | 47 34.36 | − 0.18 | + 0.74 | + 0.05 | 47 34.97 | 20 46 08.55 | 1 26.42 |
| Bradl. 2749 | ........ | 20 54 37.55 | − 0.90 | − 4.83 | + 0.31 | 20 54 32.13 | 20 53 06.07 | 1 26.06 |
| 61 Cygni | ........ | 21 02 56.23 | − 0.29 | − 0.16 | + 0.07 | 21 02 55.85 | 21 01 29.30 | 1 26.55 |
| ζ Cygni | ........ | 21 09 14.78 | − 0.27 | + 0.05 | + 0.06 | 21 09 14.62 | 21 07 48.17 | − 1 26.45 |

NORMAL EQUATIONS.

$a_0 = +1^{s}.00 \qquad c_0 = +0^{s}.15 \qquad \Delta T_0 = -1^{m}\,26^{s}.50 \qquad \text{for } 20^{h}.7$

$$\begin{aligned}
&\overset{s.}{0 = -0.155} + 7.75\,d\Delta T - 0.32\,da - 0.25\,dc \\
&0 = -0.544 - 0.32\,d\Delta T + 4.36\,da - 0.69\,dc \\
&0 = +1.744 - 0.25\,d\Delta T - 0.69\,da + 17.06\,dc
\end{aligned}$$

$$\begin{aligned}
d\Delta T &= \overset{s.}{+0.021} & \Delta T &= -\overset{m.}{1}\ \overset{s.}{26.479}\ (\text{wt.} = 7.72) \\
da &= +0.111 & a &= +\ 1.111\ (\text{wt.} = 4.32) \\
dc &= -0.097 & c &= +\ 0.053\ (\text{wt.} = 16.94)
\end{aligned}$$

*Fort Bliss, September 10, 1878; after signals.*

| Name of star. | Clamp. | T. | | | B *b*. | A *a*. | C *c*. | T′. | | | AR. | | | Δ T. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| θ Aquarii | E. | 22 | 11 | 54.08 | − 0.21 | + 0.63 | + 0.11 | 22 | 11 | 54.61 | 22 | 10 | 28.05 | − 1 | 26.56 |
| γ Aquarii | E. | | 16 | 51.60 | − 0.23 | + 0.54 | + 0.11 | | 16 | 52.02 | 22 | 15 | 25.46 | 1 | 26.56 |
| π Aquarii | E. | | 20 | 33.07 | − 0.24 | + 0.51 | + 0.11 | | 20 | 33.45 | 22 | 19 | 06.95 | 1 | 26.50 |
| 9 H. Draconis S. P | E. | | 26 | 05.45 | + 0.36 | + 3.91 | − 0.47 | | 26 | 09.25 | 22 | 24 | 42.17 | 1 | 27.08 |
| 7 Lacertæ | E. | | 27 | 47.45 | − 0.40 | − 0.46 | + 0.17 | | 27 | 46.76 | 22 | 26 | 19.83 | 1 | 26.93 |
| 226 Cephei B | E. | | 31 | 41.67 | − 0.80 | − 2.71 | + 0.45 | | 31 | 38.61 | 22 | 30 | 11.96 | 1 | 26.65 |
| λ Pegasi | W. | | 47 | 09.96 | − 0.33 | + 0.16 | − 0.12 | | 47 | 09.67 | 22 | 40 | 43.29 | 1 | 26.38 |
| λ Aquarii | W. | 22 | 47 | 45.63 | − 0.24 | + 0.63 | − 0.11 | 22 | 47 | 45.91 | 22 | 46 | 19.29 | 1 | 26.62 |
| ο Cephei | W. | 23 | 15 | 10.94 | − 0.65 | − 1.48 | − 0.29 | 23 | 15 | 08.52 | 23 | 13 | 41.78 | 1 | 26.74 |
| κ Piscium | W. | 23 | 22 | 11.21 | − 0.26 | + 0.50 | − 0.11 | 23 | 22 | 11.34 | 23 | 20 | 44.88 | − 1 | 26.46 |

NORMAL EQUATIONS.

$a_0 = +1^s.00 \qquad c_0 = +0^s.15 \qquad \Delta T_0 = -1^m\ 26^s.60 \quad \text{for } 22^h.7$

$$\begin{aligned} & \quad\ \ ^{s.} \\ 0 &= -0.063 + 7.28\, d\Delta T + 2.16\, da + 0.13\, dc \\ 0 &= +0.023 + 2.16\, d\Delta T + 7.80\, da - 4.23\, dc \\ 0 &= +0.555 + 0.13\, d\Delta T - 4.23\, da + 17.74\, dc \end{aligned}$$

$$\begin{aligned} d\Delta T &= +\overset{s.}{0.018} & \Delta T &= -\overset{m.}{1}\ \overset{s.}{26.582}\ (\text{wt.} = 6.58) \\ da &= -0.028 & a &= +\ 0.972\ (\text{wt.} = 6.14) \\ dc &= -0.038 & c &= +\ 0.112\ (\text{wt.} = 15.20) \end{aligned}$$

*Fort Bliss, September 11, 1878; before signals.*

| Name of star. | Clamp. | T. | | | B*b*. | A *a*. | C *c*. | T′. | | | A.R. | | | Δ T. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| α Delphini | W. | 20 | 35 | 29.17 | — 0.04 | + 0.20 | — 0.15 | 20 | 35 | 29.18 | 20 | 34 | 1.87 | — 1 | 27.31 |
| α Cygni | W. | | 38 | 47.39 | — 0.06 | — 0.21 | — 0.21 | | 38 | 46.91 | 20 | 37 | 19.48 | 1 | 27.43 |
| ε Cygni | W. | | 42 | 47.94 | — 0.05 | — 0.02 | — 0.18 | | 42 | 47.69 | 20 | 41 | 19.85 | 1 | 27.84 |
| μ Aquarii | W. | | 47 | 35.80 | — 0.03 | + 0.45 | — 0.15 | | 47 | 36.07 | 20 | 46 | 08.54 | 1 | 27.53 |
| Bradl. 2749 | W. | 20 | 54 | 37.48 | — 0.17 | — 2.91 | — 0.85 | 20 | 54 | 33.55 | 20 | 53 | 05.98 | 1 | 27.57 |
| 61 Cygni | E. | 21 | 02 | 56.92 | — 0.16 | — 0.10 | + 0.19 | 21 | 02 | 56.85 | 21 | 01 | 29.29 | 1 | 27.56 |
| Br. 2777 [77 Draconis] | E. | | 09 | 26.29 | — 0.42 | — 2.25 | + 0.69 | | 09 | 24.31 | 21 | 07 | 56.93 | 1 | 27.38 |
| τ Cygni | E. | 21 | 11 | 26.35 | — 0.16 | — 0.09 | + 0.19 | 21 | 11 | 26.29 | 21 | 09 | 58.71 | — 1 | 27.58 |

NORMAL EQUATIONS.

$a_0 = +0^s.65$ $c_0 = +0^s.15$ $\Delta T_0 = -1^m\ 27^s.55$ for $20^h.9$

$$
\begin{aligned}
&\phantom{=}\ \ \ s.\\
0 &= -0.077 + 5.71\, d\,\Delta T - 0.54\, da - 2.09\, dc\\
0 &= -0.090 - 0.54\, d\,\Delta T + 4.39\, da - 0.07\, dc\\
0 &= +0.074 - 2.09\, d\,\Delta T - 0.07\, da + 14.78\, dc
\end{aligned}
$$

$$
\begin{aligned}
& \qquad\quad s. & & \qquad\ \ m.\ \ s.\\
d\,\Delta T &= +0.015 & \Delta T &= -1\ 27.535\ (\text{wt.} = 5.35)\\
da &= +0.022 & a &= +\ \ 0.672\ (\text{wt.} = 4.33)\\
dc &= -0.003 & c &= +\ \ 0.147\ (\text{wt.} = 14.00)
\end{aligned}
$$

*Fort Bliss, September 11, 1878; after signals.*

| Name of star. | Clamp. | T. | | | B *b*. | A *a*. | C *c*. | ′. | | | A. R. | | | . | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| α Aquarii | E. | 22 | 01 | 02.21 | − 0.07 | + 0.85 | + 0.17 | 23 | 01 | 02.66 | 21 | 59 | 35.18 | − 1 | 27.48 |
| π Pegasi | E. | | 06 | 05.39 | − 0.10 | − 0.01 | + 0.21 | | 06 | 05.49 | 22 | 04 | 37.95 | 1 | 27.54 |
| 24 Cephei | E. | | 09 | 00.05 | − 0.21 | − 1.32 | + 0.55 | | 08 | 59.07 | 22 | 07 | 81.30 | 1 | 27.77 |
| θ Aquarii | E. | | 11 | 55.31 | − 0.06 | + 0.42 | + 0.17 | | 11 | 55.84 | 22 | 10 | 28.05 | 1 | 27.79 |
| γ Aquarii | E. | | 16 | 52.59 | − 0.07 | + 0.36 | + 0.17 | | 16 | 53.05 | 22 | 15 | 25.47 | 1 | 27.58 |
| π Aquarii | W. | | 20 | 34.33 | − 0.03 | + 0.33 | − 0.17 | | 20 | 34.46 | 22 | 19 | 06.95 | 1 | 27.51 |
| 9 H. Draconis S. P | W. | | 26 | 07.09 | + 0.04 | + 2.58 | + 0.73 | | 26 | 10.44 | 22 | 24 | 42.21 | 1 | 28.23 |
| 7 Lacertæ | W. | | 27 | 48.38 | − 0.05 | − 0.30 | − 0.27 | | 27 | 47.76 | 22 | 26 | 19.83 | 1 | 27.93 |
| 226 Cephei B | W. | | 31 | 42.04 | − 0.09 | − 1.79 | − 0.70 | | 31 | 39.46 | 22 | 30 | 11.94 | 1 | 27.52 |
| 10 Lacertæ | W. | | 35 | 19.28 | − 0.04 | − 0.10 | − 0.22 | | 35 | 18.92 | 22 | 33 | 51.13 | 1 | 27.79 |
| ζ Pegasi | W. | 22 | 36 | 54.16 | − 0.03 | + 0.24 | − 0.18 | 22 | 36 | 54.19 | 22 | 35 | 26.71 | 1 | 27.48 |
| ο Cephei | W. | 23 | 15 | 11.25 | − 0.15 | − 0.98 | − 0.45 | 23 | 15 | 09.67 | 23 | 13 | 41.78 | 1 | 27.89 |
| κ Piscium | W. | | 22 | 12.43 | − 0.08 | + 0.33 | − 0.17 | | 22 | 12.51 | 23 | 20 | 44.89 | 1 | 27.62 |
| ι Piscium | W. | | 35 | 12.42 | − 0.10 | + 0.29 | − 0.17 | | 35 | 12.44 | 23 | 33 | 44.70 | 1 | 27.74 |
| ω Piscium | W. | 23 | 54 | 34.60 | − 0.12 | + 0.28 | − 0.17 | 23 | 54 | 34.59 | 23 | 53 | 06.95 | − 1 | 27.04 |

NORMAL EQUATIONS.

$a_0 = +0^s.65 \qquad c_0 = +0^s.15 \qquad \Delta T_0 = -1^m \; 27^s.65 \qquad \text{for } 22^h.7$

$$\begin{aligned} 0 &= \overset{s.}{+0.143} + 11.20\, d\Delta T + 2.11\, da - 3.64\, dc \\ 0 &= -0.045 + 2.11\, d\Delta T + 9.60\, da + 5.50\, dc \\ 0 &= -0.554 - 3.64\, d\Delta T + 5.50\, da + 25.48\, dc \end{aligned}$$

$$\begin{aligned} d\Delta T &= \overset{s.}{-0.004} & \Delta T &= \overset{m.}{-1} \; \overset{s.}{27.654} \text{ (wt. = 9.60)} \\ da &= -0.008 & a &= + \; 0.642 \text{ (wt. = 7.63)} \\ dc &= +0.023 & c &= + \; 0.173 \text{ (wt. = 20.12)} \end{aligned}$$

*Fort Bliss, September 12, 1878; before signals.*

| Name of star. | Clamp. | T. | | | B *b*. | A *a*. | C *c*. | T′. | | | A. R. | | | Δ T. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| Groombr. 3241 | W. | 20 | 32 | 03.58 | − 0.12 | − 1.49 | − 0.82 | 20 | 32 | 01.15 | 20 | 30 | 33.46 | − 1 | 27.69 |
| α Delphini* | W. | | 35 | 29.12 | − 0.05 | + 0.21 | − 0.26 | | 35 | 29.02 | 20 | 34 | 01.86 | 1 | 27.16 |
| α Cygni | W. | | 38 | 47.70 | − 0.06 | − 0.23 | − 0.36 | | 38 | 47.05 | 20 | 37 | 19.46 | 1 | 27.59 |
| ε Cygni | W. | | 42 | 47.88 | − 0.06 | − 0.03 | − 0.30 | | 42 | 47.49 | 20 | 41 | 19.83 | 1 | 27.66 |
| μ Aquarii | W. | | 47 | 35.91 | − 0.04 | + 0.47 | − 0.26 | | 47 | 36.08 | 20 | 46 | 08.53 | 1 | 27.55 |
| Bradl. 2749 | E. | 20 | 54 | 35.22 | − 0.66 | − 3.08 | + 1.47 | 20 | 54 | 32.95 | 20 | 53 | 05.90 | 1 | 27.05 |
| 61 Cygni | E. | 21 | 02 | 57.00 | − 0.22 | − 0.10 | + 0.32 | 21 | 02 | 57.00 | 21 | 01 | 29.28 | 1 | 27.72 |
| ξ Cygni | E. | | 09 | 15.50 | − 0.20 | + 0.03 | + 0.29 | | 09 | 15.62 | 21 | 07 | 48.15 | 1 | 27.47 |
| τ Cygni | E. | 21 | 11 | 26.38 | − 0.21 | − 0.09 | + 0.32 | 21 | 11 | 26.40 | 21 | 09 | 58.70 | − 1 | 27.70 |

* NOTE.—It is quite likely (though contradicted by the original note-books) that T should read $20^h\ 35^m\ 29^s.82$. In this case we should have the *known* terms of the three normal equations equal to $-0^s.005 + 0^s.014$, and $-1^s.711$ respectively; and Δ T would become $-1^m\ 27^s.571$, $a + 0^s.694$. $c + 0^s.265$; the observation in question would give $\Delta T - 1^m\ 27^s.34$, agreeing more nearly with the final result. The final probable error for weight = 1 from three observations, now = ± $0^s.137$ would be diminished to ± $0^s.101$.

NORMAL EQUATIONS.

$a_0 = +0^s.65 \qquad c_0 = +0^s.15 \qquad \Delta T_0 = -1^m.\ 27^s.60 \qquad$ for $20^h.9$

$$
\begin{array}{l}
\qquad\ \ s. \\
0 = -0.201 + 7.00\, d\Delta T - 0.65\, da - 1.52\, dc \\
0 = -0.044 - 0.65\, d\Delta T + 4.41\, da - 1.71\, dc \\
0 = -1.507 + 4.41\, d\Delta T - 1.71\, da + 16.58\, dc
\end{array}
$$

$$
\begin{array}{rlrl}
 & \ \ s. & & \qquad s. \\
d\Delta T = & +0.056 & \Delta T = & -\ 1^m\ 27.544\ (\text{wt.} = 6.71) \\
da = & +0.058 & a = & +\ 0.708\ (\text{wt.} = 4.14) \\
dc = & +0.102 & c = & +\ 0.252\ (\text{wt.} = 15.41)
\end{array}
$$

*Fort Bliss, September 12, 1878; after signals.*

| Name of star. | Clamp. | T. | B*b*. | A*a*. | C*c*. | T′. | A. R. | ΔT. |
|---|---|---|---|---|---|---|---|---|
|  |  | *h.* *m.* *s.* | *s.* | *s.* | *s.* | *h.* *m.* *s.* | *h.* *m.* *s.* | *m.* *s.* |
| 9 H. Draconis, S. P | E. | 22 26 08.24 | + 0.25 | + 2.54 | − 0.75 | 22 26 10.28 | 22 24 42.25 | − 1 28.03 |
| 7 Lacertæ | E. | 27 47.96 | − 0.28 | − 0.30 | + 0.27 | 27 47.65 | 22 26 19.82 | 1 27.83 |
| 226 Cephei B. | E. | 31 41.12 | − 0.55 | − 1.76 | + 0.71 | 31 39.52 | 22 30 11.91 | 1 27.61 |
| 10 Lacertæ | E. | 35 19.06 | − 0.24 | − 0.09 | + 0.22 | 35 18.95 | 22 33 51.13 | 1 27.82 |
| λ Pegasi | W. | 42 11.12 | − 0.25 | + 0.11 | − 0.19 | 42 10.79 | 22 40 43.29 | 1 27.50 |
| ι Cephei | W. | 46 54.08 | − 0.47 | − 0.85 | − 0.43 | 46 52.33 | 22 45 24.55 | 1 27.78 |
| Bradl. 1508, S. P | W. | 51 32.84 | + 0.40 | + 2.95 | + 0.88 | 51 37.07 | 22 50 09.17 | 1 27.90 |
| ο Andromedæ | W. | 22 57 50.93 | − 0.29 | − 0 15 | − 0.24 | 22 57 50.25 | 22 56 22.56 | 1 27.69 |
| α Pegasi | W. | 23 00 12.98 | − 0.22 | + 0.19 | − 0.18 | 23 00 12.77 | 22 58 45.11 | 1 27.66 |
| ω Piscium | W. | 23 54 34.68 | − 0.11 | + 0.27 | − 0.18 | 23 54 34.66 | 23 53 06.96 | 1 27.70 |
| 21 Cassiopeiæ | W. | 0 39 14.27 | − 0.05 | − 1.58 | − 0.65 | 0 39 11.99 | 0 37 43.79 | 1 28.20 |
| δ Piscium | W. | 43 53.08 | − 0.01 | + 0.27 | − 0.18 | 43 53.16 | 0 42 25.32 | 1 27.84 |
| 32 Camelp., H. S. P | W. | 49 29.24 | 0.00 | + 5.50 | + 1.70 | 49 36 44 | 0 48 08.41 | 1 28.03 |
| ε Piscium | W. | 0 58 08.56 | 0.00 | + 0.26 | − 0.18 | 0 58 08.64 | 0 56 40.82 | − 1 27.82 |

NORMAL EQUATIONS.

$a_0 + 0^s.65 \qquad c_0 = +0^s.15 \qquad \Delta T_0 = -1^m\ 27^s.70$ for $23^h.5$

$$\begin{aligned}
&\overset{s.}{\phantom{0}}\\
0 &= +0.620 + 8.82\, d\Delta T + 0.99\, da - 5\ 22\, dc\\
0 &= +0.247 + 0.99\, d\Delta T + 15.43\, da + 3.51\, dc\\
0 &= -1.035 - 5.22\, d\Delta T + 3.51\, da + 32.04\, dc
\end{aligned}$$

$$\begin{aligned}
d\Delta T &= \overset{s}{-0.052} & \Delta T &= -\overset{m.}{1}\ \overset{s.}{27.752}\ (\text{wt.} = 7.81)\\
da &= -0.019 & a &= +\ 0.631\ (\text{wt.} = 14.74)\\
dc &= +0.026 & c &= +\ 0.176\ (\text{wt.} = 27.85)
\end{aligned}$$

*Ogden, September 7, 1878; before signals.*

| Name of star. | Clamp. | T. | Bb. | Aa. | Cc. | T′. | A. R. | ΔT. |
|---|---|---|---|---|---|---|---|---|
| | | h. m. s. | s. | s. | s. | h. m. s. | h. m. s. | m. s. |
| κ Lyræ | W. | 18 18 35.95 | − 0.01 | + 0.04 | − 0.18 | 18 18 35.80 | 18 15 37.69 | − 2 58.11 |
| 109 Herculis | W. | 18 21 31.13 | − 0.01 | + 0.11 | − 0.15 | 21 31.08 | 18 18 32.81 | 2 58.27 |
| χ Draconis | W. | 18 26 14.81 | − 0.01 | − 0.55 | − 0.48 | 26 13.77 | 18 23 15.51 | 2 58.26 |
| 9 Heis Lyræ | W. | 18 31 11.00 | − 0.01 | + 0.07 | − 0.17 | 31 10.89 | 18 28 12.73 | 2 58.16 |
| 11 Heis Lyræ | W. | 18 35 09.66 | − 0.01 | + 0.05 | − 0.17 | 35 09.53 | 18 32 11.43 | 2 58.10 |
| Gr. 2655 | W. | 18 38 37.12 | − 0.02 | − 0.85 | − 0.66 | 38 35.59 | 18 35 37.37 | 2 58.22 |
| 50 Draconis | E. | 18 53 16.69 | + 0.20 | − 0.69 | + 0.57 | 18 53 16.77 | 18 50 18.33 | 2 58.44 |
| ζ Aquilæ | E. | 19 02 49.38 | + 0.06 | + 0.15 | + 0.15 | 19 02 49.74 | 18 59 51.42 | 2 58.32 |
| ι Lyræ | E. | 19 05 57.45 | + 0.08 | + 0.04 | + 0.18 | 05 57.75 | 19 02 59.66 | 2 58.09 |
| 19 Lyræ | E. | 19 10 06.13 | + 0.07 | + 0.06 | + 0.17 | 10 06.43 | 19 07 08.16 | 2 58.27 |
| θ Lyræ | E. | 19 15 08.54 | + 0.08 | + 0.02 | + 0.18 | 15 08.82 | 19 12 10.75 | 2 58.07 |
| τ Draconis | E. | 19 20 52.13 | + 0.18 | − 0.57 | + 0.50 | 19 20 52.24 | 19 17 54.27 | − 2 57.97 |

NORMAL EQUATIONS.

$a_0 = +0^s.33 \qquad c_0 = +0^s.14 \qquad \Delta T_0 = -2^m\ 58^s.18$ for $19^h\ 0^m$

$$\begin{aligned}
&\overset{s.}{\phantom{0}}\\
0 &= -0.010 + 8.37\, d\Delta T - 0.41\, da + 0.08\, dc\\
0 &= +0.073 - 0.41\, d\Delta T + 4.75\, da + 0.18\, dc\\
0 &= -0,083 + 0.08\, d\Delta T + 0.18\, da + 24,15\, dc
\end{aligned}$$

$$\begin{array}{llll}
 & s. & & m.\ \ s. \\
d\Delta T & 0.000 & \Delta T = -2 & 58.180\ (\text{wt.} = 8.39) \\
da & -0.016 & a = + & 0.314\ (\text{wt.} = 4.73) \\
dc & +0.004 & c = + & 0.144\ (\text{wt.} = 24.14)
\end{array}$$

## *Ogden, September 7, 1878; after signals.*

| Name of star. | Clamp. | T. | B*b*. | A*a*. | C*c*. | T′. | R A. | ΔT. |
|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *h. m. s.* | *m. s.* |
| 39 Pegasi | E. | 22 29 44.90 | + 0.11 | − 0.57 | + 0.25 | 22 29 44.69 | 22 26 45.69 | − 2 59.00 |
| 31 Cephei | E. | 22 35 44.89 | + 0.33 | + 2.61 | + 0.80 | 35 48.63 | 22 32 49.50 | 2 59.13 |
| η Pegasi | E. | 22 40 19.69 | + 0.13 | − 0.34 | + 0.27 | 40 19.75 | 22 37 20.96 | 2 58.79 |
| λ Pegasi | E. | 22 43 42.32 | + 0.12 | − 0.49 | + 0.25 | 43 42.20 | 22 40 43.23 | 2 58.97 |
| ι Cephei | E. | 22 48 21.17 | + 0.25 | + 1.44 | + 0.56 | 22 48 23.42 | 22 45 24.49 | 2 58.93 |
| π Cephei | W. | 23 07 02.37 | + 0.41 | + 3.03 | − 0.88 | 23 07 04.93 | 23 04 06.13 | 2 58.80 |
| 130 Heis Pegasi | W. | 23 13 00.72 | + 0.13 | − 0.47 | − 0.26 | 13 00.12 | 23 10 01.07 | 2 59.05 |
| ο Cephei | W. | 23 16 39.41 | + 0.30 | + 1.66 | − 0.61 | 16 40.76 | 23 13 41.77 | 2 58.99 |
| υ Pegasi | W. | 23 22 21.03 | + 0.13 | − 0.50 | − 0.25 | 22 20.41 | 23 19 21.48 | 2 58.93 |
| 70 Pegasi | W. | 23 26 02.99 | + 0.11 | − 0.72 | − 0.24 | 26 02.14 | 23 23 03.18 | 2 58.96 |
| 72 Pegasi | W. | 23 30 57.55 | + 0.15 | − 0.31 | − 0.27 | 23 30 57.12 | 23 27 58.12 | − 2 59.00 |

NORMAL EQUATIONS.

$a_0 = -1^{s}.45 \quad c_0 = +0^{s}.22 \quad \Delta T_0 = -2^{m}.58^{s}.98$ for $23^{h}.0$

$$
\begin{aligned}
&\phantom{0 = -\,}\textit{s.}\\
0 &= -0.155 + 8.08\, d\Delta T + 0.06\, da - 0{,}90\, dc\\
0 &= -0.009 + 0.06\, d\Delta T + 3.74\, da - 0.30\, dc\\
0 &= -0.247 - 0.90\, d\Delta T - 0.30\, da + 20.75\, dc
\end{aligned}
$$

$$
\begin{aligned}
&&& \quad\textit{m.}\quad \textit{s.}\\
a\Delta T &= +\ 0.021 & \Delta T &= --2\ 58.959\ (\text{wt.} = 8.04)\\
d a &= +\ 0.003 & a &= -\ 1.447\ (\text{wt.} = 3.74)\\
d c &= +\ 0.013 & c &= +\ 0.233\ (\text{wt.} = 20.63)
\end{aligned}
$$

*Ogden, September* 8, 1878; *before signals.*

| Name of star. | Clamp. | T. | | | B*b*. | A*a*. | C*c*. | T′. | | | A. R. | | | Δ T. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| 109 Herculis | W. | 18 | 21 | 35.25 | + 0.05 | − 0.30 | − 0.26 | 18 | 21 | 34.65 | 18 | 18 | 32.80 | − 3 | 1.85 |
| χ Draconis | W. | 18 | 26 | 16.36 | + 0.13 | + 1.90 | − 0.81 | | 26 | 17.58 | 18 | 23 | 15.43 | 3 | 2.15 |
| 9 Heis Lyræ | W. | 18 | 31 | 15.00 | + 0.05 | − 0.24 | − 0.28 | | 31 | 14.53 | 18 | 28 | 12.71 | 3 | 1.82 |
| 11 Heis Lyræ | W. | 18 | 35 | 13.76 | + 0.06 | − 0.18 | − 0.29 | | 35 | 13.35 | 18 | 32 | 11.41 | 3 | 1.94 |
| Gr. 2655 | W. | 18 | 38 | 36.92 | + 0.17 | + 2.96 | − 1.11 | | 38 | 38.94 | 18 | 35 | 37.27 | 3 | 1.67 |
| 110 Herculis | W. | 18 | 43 | 30.33 | + 0.05 | − 0.41 | − 0.26 | 18 | 43 | 29.71 | 18 | 40 | 27.76 | 3 | 1.95 |
| ζ Aquilæ | E. | 19 | 02 | 53.62 | + 0.02 | − 0.52 | + 0.25 | 19 | 02 | 53.37 | 18 | 59 | 51.41 | 3 | 1.96 |
| ι Lyræ | E. | 19 | 06 | 01.24 | + 0.02 | − 0.12 | + 0.30 | | 06 | 01.44 | 19 | 02 | 59.63 | 3 | 1.81 |
| 19 Lyræ | E. | 19 | 10 | 10.00 | + 0.02 | − 0.22 | + 0.28 | | 10 | 10.08 | 19 | 07 | 08.14 | 3 | 1.94 |
| δ Draconis | E. | 19 | 15 | 32.90 | + 0.05 | + 1.25 | + 0.63 | | 15 | 34.83 | 19 | 12 | 32.81 | 3 | 2.02 |
| τ Draconis | E. | 19 | 20 | 53.07 | + 0.06 | + 1.98 | + 0.83 | | 20 | 55.94 | 19 | 17 | 54.20 | 3 | 1.74 |
| 4 Cygni | E. | 19 | 24 | 50.03 | + 0.02 | − 0.12 | + 0.30 | 19 | 24 | 50.22 | 19 | 21 | 48.31 | − 3 | 1.92 |

NORMAL EQUATIONS.

$a_0 = -1^{s}.10 \qquad c_0 - + 0^{s}.23 \qquad \Delta T_0 = -3^{m}\ 1^{s}.90$ for $19^{h}.0$

$$
\begin{array}{l}
\qquad\ \ s. \\
0 = +\,0.027 + 8.66\, d\,\Delta T - 0.08\, da + 0.36\, dc \\
0 = -\,0.061 - 0.08\, d\,\Delta T + 4.34\, da + 0.67\, dc \\
0 = -\,0.260 + 0.36\, d\,\Delta T + 0.67\, da + 23.18\, dc
\end{array}
$$

$$
\begin{array}{rlrl}
 & & & m. \quad s. \\
d\,\Delta T = & -\,0.003 & \Delta T = & -\,3 \quad 1.903\ (\text{wt.} = 8.65) \\
da = & +\,0.012 & a = & - \qquad 1.088\ (\text{wt.} = 4.32) \\
dc = & +\,0.011 & c = & + \qquad 0.241\ (\text{wt.} = 23.07)
\end{array}
$$

*Ogden, September 8, 1878; after signals.*

| Name of star. | Clamp. | T. | B *b* | A *a* | C *c* | T′. | A. R. | Δ T. |
|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *h. m. s.* | *m. s.* |
| 11 Cephei | E. | 21 43 10.86 | + 0.45 | + 1.71 | + 0.62 | 21 43 13.64 | 21 40 11.15 | − 3 2.49 |
| 16 Pegasi | E. | 21 50 36.83 | + 0.15 | − 0.34 | + 0.23 | 50 36.87 | 21 47 34.43 | 3 2.44 |
| 17 Pegasi | E. | 21 54 06.18 | + 0.12 | − 0.58 | + 0.21 | 54 05.93 | 21 51 03.44 | 3 2.49 |
| 20 Pegasi | E. | 21 58 15.52 | + 0.11 | − 0.56 | + 0.21 | 21 58 15.28 | 21 55 12.68 | 3 2.60 |
| 27 Pegasi | E. | 22 06 55.29 | + 0.12 | − 0.20 | + 0.24 | 22 06 55.45 | 22 03 53.05 | 3 2.40 |
| 24 Cephei | E. | 22 10 30.72 | + 0.27 | + 1.85 | + 0.65 | 10 33.49 | 22 07 31.28 | 3 2.21 |
| 33 Pegasi | W. | 22 27 33.54 | + 0.02 | − 0.22 | − 0.24 | 27 33.10 | 22 24 30.85 | 3 2.25 |
| Gr. 3804 | W. | 22 30 09.30 | + 0.03 | − 0.05 | − 0.26 | 30 09.02 | 22 27 06.63 | 3 2.39 |
| 31 Cephei | W. | 22 35 50.81 | + 0.06 | + 2.06 | − 0.70 | 35 52.23 | 22 32 49.48 | 3 2.75 |
| η Pegasi | W. | 22 40 23.80 | + 0.02 | − 0.26 | − 0.23 | 40 23.33 | 22 37 20.97 | 3 2.36 |
| λ Pegasi | W. | 22 43 46.28 | + 0.02 | − 0.39 | − 0.22 | 22 43 45.69 | 22 40 43.23 | − 3 2.46 |

NORMAL EQUATIONS.

$a_0 = -1^s.10 \qquad c_0 = +0^s.23 \qquad \Delta T_0 = -3^m\, 2^s.48 \qquad \text{for } 22^h.0$

$$
\begin{aligned}
&\phantom{0=+}^{s.}\\
0 &= +0.028 + 8.48\, d\Delta T + 0.64\, da + 0.92\, dc\\
0 &= +0.113 + 0.64\, d\Delta T + 3.35\, da - 0.80\, dc\\
0 &= +0.468 + 0.92\, d\Delta T - 0.80\, da + 19.41\, dc
\end{aligned}
$$

$$
\begin{aligned}
& & &\phantom{=-}{}^{m.\ s.}\\
d\Delta T &= +0.003 & \Delta T &= -3\ \ 2.427\ (\text{wt.} = 8.30)\\
da &= -0.041 & a &= -\ \ 1.141\ (\text{wt.} = 3.26)\\
dc &= -0.026 & c &= +\ \ 0.204\ (\text{wt.} = 19.08)
\end{aligned}
$$

*Ogden, September 10, 1878; before signals.*

| Name of star. | Clamp. | T. | B*b*. | A*a*. | C*c*. | T'. | A.R. | Δ T. |
|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *h. m. s.* | *m. s.* |
| χ Draconis | E. | 18 26 16.24 | + 0.31 | + 0.37 | + 0.68 | 18 26 17.60 | 18 23 15.26 | — 3 2.34 |
| 9 Heis Lyræ | E. | 18 31 14.73 | + 0.12 | — 0.04 | + 0.23 | 31 15.04 | 18 28 12.67 | 3 2.37 |
| 110 Herculis | E. | 18 43 29.79 | + 0.11 | — 0.08 | + 0.21 | 43 30.03 | 18 40 27.73 | 3 2.30 |
| β Lyræ | E. | 18 48 39.08 | + 0.13 | — 0.03 | + 0.24 | 48 39.42 | 18 45 37.15 | 3 2.27 |
| 50 Draconis | E. | 18 53 18.80 | + 0.36 | + 0.46 | + 0.80 | 53 20.42 | 18 50 18.10 | 3 2.32 |
| γ Lyræ | E. | 18 57 27.41 | + 0.13 | — 0.04 | + 0.24 | 18 57 27.74 | 18 54 25.57 | 3 2.17 |
| τ Draconis | W. | 19 20 56.49 | + 0.25 | + 0.38 | — 0.70 | 19 20 56.42 | 19 17 54.06 | 3 2.36 |
| 4 Cygni | W. | 19 24 50.57 | + 0.11 | — 0.02 | — 0.25 | 24 50.41 | 19 21 48.27 | 3 2.14 |
| β Cygni | W. | 19 28 53.49 | + 0.09 | — 0.05 | — 0.23 | 28 53.30 | 19 25 51.11 | 3 2.19 |
| 9 Cygni | W. | 19 33 05.53 | + 0.10 | — 0.05 | — 0.23 | 33 05.35 | 19 30 02.09 | 3 2.36 |
| φ Cygni | W. | 19 37 39.04 | + 0.10 | — 0.05 | — 0.23 | 37 38.86 | 19 34 36.43 | 3 2.43 |
| ε Draconis | W. | 19 51 38.64 | + 0.22 | + 0.29 | — 0.59 | 19 51 38.56 | 19 48 36.30 | — 3 2.26 |

NORMAL EQUATIONS.

$$a_0 = -0^s.20 \qquad c_0 = +0^s.20 \qquad \Delta T_0 = -3^m\,2^s.28 \text{ for } -19^h.0$$

$$\begin{aligned} &\phantom{0 = +\ } s. \\ 0 &= +0.012 + 8{\cdot}60\, d\,\Delta T - 0.40\, da - 0.17\, dc \\ 0 &= +0.035 - 0.40\, d\,\Delta T + 4.12\, da - 0.36\, dc \\ 0 &= -0.030 - 0.17\, d\,\Delta T - 0.36\, da + 23.37\, dc \end{aligned}$$

$$\begin{aligned} &\phantom{d\,\Delta T = -\ } s. \qquad\qquad\qquad m.\ \ s. \\ d\,\Delta T &= -0.002 \quad \Delta T = -3\ 2.282 \text{ (wt. = 8.56)} \\ da &= -0.009 \quad a = -\ 0.209 \text{ (wt. = 4.10)} \\ dc &= -0.002 \quad c = +\ 0.202 \text{ (wt. = 23.34)} \end{aligned}$$

### *Ogden, September 10, 1878; after signals.*

| Name of star. | Clamp. | T. | Bb. | Aa. | Cc. | T′. | A. R. | Δ T. |
|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *h. m. s.* | *m. s.* |
| ι Pegasi | W. | 22 04 25.82 | + 0.20 | + 0.01 | − 0.22 | 22 04 25.81 | 22 01 23.69 | − 3 2.12 |
| 24 Cephei | W. | 22 10 33.59 | + 0.52 | − 0.08 | − 0.65 | 10 33.38 | 22 07 31.24 | 3 2.14 |
| 31 Pegasi | W. | 22 18 37.22 | + 0.17 | + 0.02 | − 0.21 | 18 37.20 | 22 15 34.75 | 3 2.45 |
| 38 Pegasi | W. | 22 27 33.19 | + 0.22 | + 0.01 | − 0.24 | 27 33.18 | 22 24 30.85 | 3 2.33 |
| η Pegasi | E. | 22 40 22.50 | + 0.29 | + 0.01 | + 0.23 | 40 23.03 | 22 37 20.97 | 3 2.06 |
| λ Pegasi | E. | 22 43 44.94 | + 0.26 | + 0.02 | + 0.22 | 43 45.44 | 22 40 43.23 | 3 2.21 |
| ι Cephei | E. | 22 48 25.82 | + 0.56 | − 0.05 | + 0.49 | 22 48 26.82 | 22 45 24.49 | 3 2.33 |
| β Pegasi | E. | 23 00 57.41 | + 0.28 | + 0.01 | + 0.23 | 23 00 57.93 | 22 57 55.60 | 3 2.33 |
| π Cephei | E. | 23 07 07.01 | + 0.81 | − 0.10 | + 0.77 | 23 07 08.49 | 23 04 06.13 | − 3 2.36 |

NORMAL EQUATIONS.

$a_0 = 0.00 \qquad c_0 = +\,0^s.20 \qquad \Delta T_0 = -\,3^m,\ 2^s.24$ for $22^h.5$

$$\begin{aligned} 0 &= +\overset{s.}{0.106} + 6.72\,d\,\Delta T + 0.26\,da + 1.08\,dc \\ 0 &= -0.128 + 0.26\,d\,\Delta T + 2.97\,da - 1.56\,dc \\ 0 &= +0.031 + 1.08\,d\,\Delta T - 1.56\,da + 16.57\,dc \end{aligned}$$

$$\begin{aligned} d\,\Delta T &= -\overset{s.}{0.018} & \Delta T &= -\overset{m.}{3}\ \overset{s.}{[2.258}\ (\text{wt.} = 6.60) \\ da &= +0.047 & a &= +\ 0.047\ (\text{wt.} = 2.80) \\ dc &= +0.004 & c &= +\ 0.204\ (\text{wt.} = 15.54) \end{aligned}$$

*Ogden, September 11, 1878; before signals.*

| Name of star. | Clamp. | T. | B*b*. | A*a*. | C*c*. | T′. | A.R. | ΔT. |
|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *h. m. s.* | *m. s.* |
| ξ Herculis | E. | 17 56 03.17 | + 0.29 | + 0.02 | + 0.19 | 17 56 03.67 | 17 53 03.85 | — 2 59.82 |
| o Herculis | E. | 18 05 48.86 | + 0.29 | + 0.02 | + 0.19 | 18 05 49.36 | 18 02 49.55 | 2 59.81 |
| A Herculis | E. | 18 10 20.61 | + 0.30 | + 0.02 | + 0.19 | 10 21.12 | 18 07 21.26 | 2 59.86 |
| κ Lyræ | E. | 18 18 36.85 | + 0.32 | + 0.01 | + 0.21 | 18 37.39 | 18 15 37.60 | 2 59.79 |
| χ Draconis | E. | 18 26 13.58 | + 0.75 | — 0.15 | + 0.55 | 26 14.73 | 18 23 15.20 | 2 59.53 |
| Gr. 2655 | W. | 18 38 36.93 | + 0.97 | — 0.23 | — 0.76 | 38 36.91 | 18 35 36.96 | 2 59.95 |
| β Lyræ | W. | 18 48 37.03 | + 0.08 | + 0.01 | — 0.20 | 48 36 92 | 18 45 37.13 | 2 59.79 |
| δ¹ Lyræ | W. | 18 53 16.70 | + 0.08 | + 0.01 | — 0.21 | 53 16.58 | 18 50 16.77 | 2 59.81 |
| γ Lyræ | W. | 18 57 25.34 | + 0.08 | + 0.02 | — 0.20 | 18 57 25.24 | 18 54 25.56 | 2 59.68 |
| ζ Aquilæ | W. | 19 02 51.42 | + 0.06 | + 0.04 | — 0.17 | 19 02 51.35 | 18 59 51.37 | 2 59.98 |
| δ Draconis | W. | 19 15 32.51 | + 0.16 | — 0.10 | — 0.43 | 19 15 32.14 | 19 12 32.67 | — 2 59.47 |

NORMAL EQUATIONS.

$a_0 = 0.00 \qquad c_0 = +0^s.20 \qquad \Delta T_0 = -2^m\ 59^s.80$ for $19^h\ 0^m$

$$\begin{aligned} 0 &= -0.097 + 8.28\, d\Delta T + 0.11\, da - 0.92\, dc \\ 0 &= -0.226 + 0.11\, d\Delta T + 3\ 24\, da + 1.63\, dc \\ 0 &= +0.562 - 0.92\, d\Delta T + 1.63\, da + 20.09\, dc \end{aligned}$$

$$\begin{aligned} d\Delta T &= \overset{s.}{+0.007} & \Delta T &= -\overset{m.}{2}\ \overset{s.}{59.793}\ (\text{wt.} = 8.23) \\ da &= +0.087 & a &= +\ 0.087\ (\text{wt.} = 3.11) \\ dc &= 0.035 & c &= +\ 0.165\ (\text{wt.} = 19.17) \end{aligned}$$

### *Ogden, September 11, 1878; after signals.*

| Name of star. | Clamp. | T. | | | B *b*. | A *a*. | C *c*. | T'. | | | A. R. | | | ΔT. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| 16 Pegasi | W. | 21 | 50 | 33.82 | + 0.24 | − 0.04 | − 0.19 | 21 | 50 | 33.83 | 21 | 47 | 34.42 | − 2 | 59.41 |
| 17 Pegasi | W. | 21 | 54 | 03.04 | + 0.20 | − 0.06 | − 0.17 | | 54 | 03.01 | 21 | 51 | 03.43 | 2 | 59.58 |
| 20 Pegasi | W. | 21 | 58 | 12.46 | + 0.21 | − 0.06 | − 0.17 | 21 | 58 | 12.44 | 21 | 55 | 12.68 | 2 | 59.76 |
| 27 Pegasi | W. | 22 | 06 | 52.44 | + 0.27 | − 0.02 | − 0.21 | 22 | 06 | 52.48 | 22 | 03 | 53.04 | 2 | 59.44 |
| 24 Cephei | W. | 22 | 10 | 30.43 | + 0.63 | + 0.19 | − 0.55 | | 10 | 30.70 | 22 | 07 | 31.22 | 2 | 59.48 |
| 31 Cephei | E. | 22 | 35 | 47.64 | + 0.87 | + 0.22 | + 0.59 | | 35 | 49.32 | 22 | 32 | 49.45 | 2 | 59.87 |
| η Pegasi | E. | 22 | 40 | 19.85 | + 0.34 | − 0.03 | + 0.20 | | 40 | 20.36 | 22 | 37 | 20.97 | 2 | 59.39 |
| λ Pegasi | E. | 22 | 43 | 42.33 | + 0.31 | − 0.04 | + 0.19 | | 43 | 42.79 | 22 | 40 | 43.34 | 2 | 59.45 |
| ι Cephei | E. | 22 | 48 | 22.67 | + 0.63 | + 0.12 | + 0.42 | 22 | 48 | 23.84 | 22 | 45 | 24.49 | − 2 | 59.36 |

NORMAL EQUATIONS.

$a_0 = 0 \qquad c_0 = +0^s.20 \qquad \Delta T_0 = -2^m\ 59^s.55$ for $22^h.5$

$$\begin{aligned} &\quad\ \ {}^{s.}\\ 0 &= -0.145 + 6.81\, d\Delta T + 0.48\, da - 0.93\, dc \\ 0 &= +0.293 + 0.48\, d\Delta T + 3.02\, da - 2.17\, dc \\ 0 &= +0.200 - 0.98\, d\Delta T - 2.17\, da + 16.28\, dc \end{aligned}$$

$$\begin{aligned} d\Delta T &= +\overset{s.}{0.026} & \Delta T &= -\overset{m.}{2}\ \overset{s.}{59.524}\ (\text{wt.} = 6.71) \\ da &= -0.120 & a &= -\ 0.120\ (\text{wt.} = 2.71) \\ dc &= -0.027 & c &= +\ 0.173\ (\text{wt.} = 14.68) \end{aligned}$$

*Ogden, September 12, 1878; before signals.*

| Name of star. | | Clamp. | T. | | | Bb. | Aa. | Ca. | T′. | | | A. R. | | | ΔT. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | h. | m. | s. | s. | | s. | h. | m. | s. | h. | m. | s. | | |
| o | Herculis | E. | 18 | 05 | 46.82 | + 0.26 | − 0.03 | + 0.17 | 18 | 05 | 47.22 | 18 | 02 | 49.53 | − 2 | 57.69 |
| A | Herculis | E. | | 10 | 18.39 | + 0.27 | − 0.02 | + 0.18 | | 10 | 18.82 | 18 | 07 | 21.24 | 2 | 57.58 |
| χ | Draconis | E. | | 26 | 11.49 | + 0.60 | + 0.20 | + 0.51 | | 26 | 12.80 | 18 | 23 | 14.94 | 2 | 57.86 |
| 9 | Heis Lyræ | E. | | 31 | 09.92 | + 0.18 | − 0.02 | + 0.18 | | 31 | 10.26 | 18 | 28 | 12.63 | 2 | 57.63 |
| | Groombr. 2655 | E. | | 38 | 32.57 | + 0.48 | + 0.31 | + 0.70 | | 38 | 34.06 | 18 | 35 | 36.85 | 2 | 57.21 |
| 110 | Herculis | E. | | 43 | 24.88 | + 0.11 | − 0.04 | + 0.16 | | 43 | 25.11 | 18 | 40 | 27.69 | 2 | 57.42 |
| 50 | Draconis | W. | 18 | 53 | 15.75 | + 0.24 | + 0.25 | − 0.60 | 18 | 53 | 15.64 | 18 | 50 | 17.89 | 2 | 57.75 |
| ζ | Aquilæ | W. | 19 | 02 | 49.11 | + 0.07 | − 0.05 | − 0.16 | 19 | 02 | 48.97 | 18 | 59 | 51.34 | 2 | 57.63 |
| ι | Lyræ | W. | | 05 | 57.21 | + 0.09 | − 0.01 | − 0.19 | | 05 | 57.10 | 19 | 02 | 59.56 | 2 | 57.54 |
| 19 | Lyræ | W. | | 10 | 05.71 | + 0.09 | − 0.02 | − 0.18 | | 10 | 05.60 | 19 | 07 | 08.07 | 2 | 57.53 |
| θ | Lyræ | W. | | 15 | 08.36 | + 0.09 | − 0.01 | − 0.19 | | 15 | 08.25 | 19 | 12 | 10.65 | 2 | 57.60 |
| τ | Draconis | W. | 19 | 20 | 51.45 | + 0.22 | − 0.21 | − 0.53 | 19 | 20 | 51.35 | 19 | 17 | 53.92 | − 2 | 57.43 |

NORMAL EQUATIONS.

$$a_0 = -0^s.20 \qquad c_0 = +0^s.20 \qquad \Delta T_0 = -2^m\,57^s.58 \text{ for } 19^h.0$$

$$\begin{aligned}
&\overset{s.}{0 = -0.010} + 8.44\,d\Delta T - 0.23\,da - 0.15\,dc\\
&0 = -0.410 - 0.23\,d\Delta T + 4.83\,da + 0.02\,dc\\
&0 = +1.121 - 0.15\,d\Delta T + 0.02\,da + 23.96\,dc
\end{aligned}$$

$$\begin{aligned}
d\Delta T &= +\overset{s.}{0.003} & \Delta T &= -\overset{m.}{2}\ \overset{s.}{57.577}\ (\text{wt.} = 8.43)\\
da &= +0.085 & a &= -\ 0.115\ (\text{wt} = 4.82)\\
dc &= -0.047 & c &= +\ 0.153\ (\text{wt.} = 23.96)
\end{aligned}$$

*Ogden, September 12, 1878; after signals.*

| Name of star. | Clamp. | T. | | | B *b*. | A *a*. | C *c*. | T'. | | | A. R. | | | Δ T. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | h. | m. | s. | s. | s. | s. | h. | m. | s. | h. | m. | s. | m. | s. |
| 16 Pegasi | W. | 21 | 50 | 31.72 | + 0.14 | — 0.09 | — 0.18 | 21 | 50 | 31.59 | 21 | 47 | 34.41 | — 2 | 57.18 |
| 17 Pegasi | W. | | 54 | 0.76 | + 0.11 | — 0.15 | — 0.17 | | 54 | 00.55 | 21 | 51 | 03.42 | 2 | 57.18 |
| 20 Pegasi | W. | 21 | 58 | 10.26 | + 0.11 | — 0.15 | — 0.17 | 21 | 58 | 10.05 | 21 | 55 | 12.67 | 2 | 57.38 |
| $\pi^1$ Pegasi | W. | 22 | 06 | 50.40 | + 0.15 | — 0.05 | — 0.19 | 22 | 06 | 50.31 | 22 | 03 | 53.04 | 2 | 57.27 |
| 24 Cephei | W. | | 10 | 28.51 | + 0.35 | + 0.49 | — 0.52 | | 10 | 28.83 | 22 | 07 | 31.20 | 2 | 57.63 |
| 31 Pegasi | E. | | 18 | 32.04 | + 0.12 | — 0.15 | + 0.17 | | 18 | 32.18 | 22 | 15 | 34.75 | 2 | 57.48 |
| Piazzi XXII. 113 | E. | | 25 | 11.98 | + 0.16 | — 0.06 | + 0.19 | | 25 | 12.27 | 22 | 22 | 14.75 | 2 | 57.52 |
| 38 Pegasi | E. | | 27 | 27.80 | + 0.16 | — 0.06 | + 0.19 | | 27 | 28.09 | 22 | 24 | 30.85 | 2 | 57.24 |
| Piazzi XXII. 158 | E. | | 32 | 57.59 | + 0.14 | — 0.12 | + 0.17 | | 32 | 57.78 | | | | | |
| 31 Cephei | E. | | 35 | 45.12 | + 0.41 | + 0.54 | + 0.56 | | 35 | 46.63 | 22 | 32 | 49.44 | 2 | 57.19 |
| λ Pegasi | E. | | 43 | 40.42 | + 0.14 | — 0.10 | + 0.18 | | 43 | 40.64 | 23 | 40 | 43.24 | 2 | 57.40 |
| ι Cephei | E. | 22 | 48 | 20.60 | + 0.31 | + 0.30 | + 0.40 | 22 | 48 | 21.61 | 22 | 45 | 24.48 | — 2 | 57.13 |

NORMAL EQUATIONS.

$a_0 = -0^s.20 \quad c_0 = +0^s.20 \quad \Delta T_0 = -2^m\ 57^s.33$ for $22^h.5$

$$
\begin{aligned}
& \quad\ \ \text{s.} \\
0 &= +0.014 + 8.71\ d\,\Delta T + 1.12\ da + 1.17\ dc \\
0 &= +0.265 + 1.12\ d\,\Delta T + 3.29\ da - 1.48\ dc \\
0 &= +0.504 + 1.17\ d\,\Delta T - 1.48\ da + 18.61\ dc
\end{aligned}
$$

$$
\begin{aligned}
& \qquad\quad \text{s.} \qquad\qquad\qquad\quad \text{m.}\quad \text{s.} \\
d\,\Delta T &= +0.016 \quad \Delta T = -2\ \ 57.314\ (\text{wt.} = 8.18) \\
da &= -0.102 \quad a = -\ \ 0.302\ (\text{wt.} = 3.00) \\
dc &= -0.036 \quad c = +\ \ 0.164\ (\text{wt.} = 17.61)
\end{aligned}
$$

***Final results of longitude.***

| Signals sent from— | Recorded at— | Mean of signals sent and received. | Time corrections. | Corrected time. | Difference of longitude. | Double wave time. | |
|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *h. m. s.* | *h. m. s.* | *m. s.* | | *m. s.* |
| **Sept. 7, 1878:** | | | | | | | |
| **Ogden** | Ogden | 21 54 14.00 | − 2 58.71 | 21 51 15.29 | | | |
| | Fort Bliss | 13 6 58.95 | +9 6 19.78 | 22 13 18.73 | 22 3.44 | | |
| **Fort Bliss** | Ogden | 22 11 38.63 | − 2 58.75 | 22 8 89.88 | | | |
| | Fort Bliss | 13 24 20.00 | +9 6 22.71 | 22 30 42.71 | 22 2.83 | 0.61 | 22 3.135 |
| **Sept. 8, 1878:** | | | | | | | |
| **Ogden** | Ogden | 21 1 0.00 | − 3 2.20 | 20 57 57.80 | | | |
| | Fort Bliss | 12 9 48.03 | +9 10 13.30 | 21 20 1.33 | 22 3.53 | | |
| **Fort Bliss** | Ogden | 21 19 45.58 | − 3 2.24 | 21.16 43.34 | | | |
| | Fort Bliss | 12 28 30.00 | +9 10 16.45 | 21 38 46.45 | 22 3.11 | 0.42 | 3.320 |
| **Sept. 10, 1878:** | | | | | | | |
| **Ogden** | Ogden | 21 8 52.00 | − 3 2.27 | 21 5 49.73 | | | |
| | Fort Bliss | 12 9 36.91 | +9 18 16.52 | 21 27 53.43 | 22 3.70 | | |
| **Fort Bliss** | Ogden | 21 30 55.29 | − 3 2.26 | 21 27 53.03 | | | |
| | Fort Bliss | 12 31 36.00 | +9 18 20.23 | 21 49 56.23 | 22 3.20 | 0.50 | 3.450 |
| **Sept. 11, 1878:** | | | | | | | |
| **Ogden** | Ogden | 21 10 2.00 | − 2 59.61 | 21 7 2.39 | | | |
| | Fort Bliss | 12 6 46.45 | +9 22 19.37 | 21 29 5.82 | 22 3.43 | | |
| **Fort Bliss** | Ogden | 21 17 29.02 | − 2 59.60 | 21 14 29.42 | | | |
| | Fort Bliss | 12 14 12.00 | +9 22 20.61 | 21 36 32.61 | 22 3.19 | 0.24 | 3.310 |
| **Sept. 12, 1878:** | | | | | | | |
| **Ogden** | Ogden | 21 19 38.00 | − 2 57.40 | 21 16 40.60 | | | |
| | Fort Bliss | 12 12 21.23 | +9 26 22.67 | 21 38 43 90 | 22 3.30 | | |
| **Fort Bliss** | Ogden | 21 25 45.97 | − 2 57.39 | 21 22 48.58 | | | |
| | Fort Bliss | 12 18 28 00 | +9 26 23.70 | 21 44 51.70 | 22 3.12 | 0.18 | 22 3.210 |

Final difference of longitude: $22^{m}\ 3^{s}.285 \pm 0^{s}.036$.
or, $5^{c}\ 30'\ 49''.27 \pm 0.''54$.

Subtracting this from the longitude of Ogden, 111° 59′ 54″.64 as given in Vol. II, page 489, of the quarto reports of this survey, we obtain 106° 29′ 5″.37 for the longitude of Fort Bliss; that is, for the astronomical monument in the public square of the village of El Paso, El Paso County, Texas.

The personal equation between Mr. Rock and Professor Safford was thus determined by an apparatus, by five groups of observations.

| Rock—Safford. 1879. | *s.* |
|---|---|
| First group, April 14, p. m | −0.142 |
| Second group, April 15, a. m | −0.026 |
| Third group, April 15, a. m | +0.051 |
| Fourth group, April 15, p. m | +0.063 |
| Fifth group, April 15, p. m | +0.255 |
| Mean | +0.044 |

This value has been neglected as too uncertain. The numbers (with their proper signs) are to be applied to the clock corrections given by Professor Safford.

*Mean place of stars for* 1878.0 *used for the determination of latitude of Fort Bliss, Tex.*

| No. of pair. | No. B.A.C. | Class. | Right Ascension. | Declination. |
|---|---|---|---|---|
| | | | *h. m. s.* | ° ′ ″ |
| | 6143 | A. | 18 1 34 | + 9 32 52.2 |
| | 6185 | A. | 8 2 | 54 15 1.8 |
| | 6203 | A. | 11 51 | 42 7 6.8 |
| | 6231 | A. | 15 8 | 21 54 39.5 |
| | 6251 | A. | 18 30 | 21 42 55.8 |
| | 6268 | A. | 20 13 | 39 26 30.0 |
| | 6300 | A. | 24 32 | 23 47 10.6 |
| | 6348 | C. | 30 28 | 56 57 9.4 |
| | [1] | D. | 30 43 | 6 34 55.0 |
| | [2] | C. | 33 1 | 43 7 8.9 |
| | 6387 | A. | 40 32 | 20 25 50.4 |
| | [3] | C. | 43 21 | 31 37 9.4 |
| | 6427 | A. | 45 19 | 32 24 41.1 |
| | 6460 | A. | 50 9 | 4 2 46.8 |
| | 6463 | AA. | 49 24 | 59 14 22.2 |
| | 6476 | C. | 51 34 | 48 42 27.2 |
| | 6487 | AA. | 54 5 | 14 54 14.0 |
| | [4] | D. | 57 9 | 50 21 43.0 |
| | 6528 | AA. | 18 59 48 | 18 41 0.2 |
| | 6553 | A. | 19 2 49 | 32 18 38.3 |
| | 6571 | A. | 7 5 | 31 4 51.5 |
| | 6599 | A. | 12 8 | 37 55 1.9 |
| | 6637 | A. | 17 51 | 26 1 46.0 |
| | 6667 | A. | 21 45 | 36 4 26.7 |
| | 6690 | A. | 25 48 | 27 42 16.3 |
| | 6709 | A. | 29 13 | 19 30 29.4 |
| | 6731 | C. | 32 51 | 44 25 33.0 |
| | 6734 | A. | 33 10 | 49 56 21.1 |
| | [5] | C. | 35 26 | 13 32 1.4 |
| | 6748 | B. | 35 56 | 54 41 15.8 |
| | 6802 | AA. | 44 50 | 8 32 50.3 |
| | 6833 | AA. | 49 19 | 6 6 11.6 |
| | 6847 | B. | 50 47 | 57 12 14.8 |
| | 6893 | A. | 19 58 11 | 6 56 5.2 |
| | 6976 | A. | 20 10 33 | 56 11 41.3 |
| | 6979 | A. | 11 34 | 24 17 46.8 |
| | 7008 | A. | 15 50 | 39 1 9.7 |
| | 7062 | A. | 23 19 | 48 58 45.0 |
| | 7085 | A. | 26 17 | 48 32 31.8 |
| | 7091 | A. | 27 33 | 48 48 32.4 |
| | 7107 | B. | 29 36 | 14 15 16.4 |
| | 7121 | A. | 31 50 | 14 10 18.6 |
| | 7160 | A. | 35 34 | 14 8 59.8 |
| | 7173 | A. | 37 46 | 14 38 16.8 |
| | 7213 | AA. | 20 42 39 | 36 2 35.2 |
| | 7256 | AA. | 49 21 | 27 35 40.1 |
| | 7271 | A. | 20 52 33 | 10 22 9.5 |
| | 7332 | C. | 21 0 4 | 52 48 1.7 |
| | 7365 | A. | 6 29 | 53 3 55.3 |
| | [6] | C. | 20 54 10 | 16 21 3.0 |
| | 7301 | A. | 55 41 | 47 2 42.6 |
| | 7345 | A. | 21 2 24 | 47 9 31.2 |
| | 7368 | AA. | 7 45 | 29 43 38.1 |
| | 7399 | B. | 12 54 | 34 23 7.5 |
| | 7410 | A. | 15 33 | 23 20 34.0 |
| | 7474 | A. | 24 25 | 23 6 17.4 |
| | 7521 | A. | 32 3 | 39 51 57.7 |
| | 7555 | C. | 36 41 | 54 19 4.1 |
| | 7561 | AA. | 38 12 | 9 18 58.6 |
| | [7] | C. | 43 26 | 38 4 55.6 |
| | 7627 | AA. | 47 31 | 25 21 6.3 |
| | 7641 | A. | 50 59 | 11 29 52.1 |
| | 7676 | B. | 57 22 | 52 17 40.2 |
| | 7688 | AA. | 21 59 31 | − 0 54 42.8 |
| | 7700 | A. | 22 0 15 | + 64 2 0.7 |
| | 7723 | A. | 4 3 | 5 35 53.6 |
| | 7749 | A. | 6 37 | 57 36 0.8 |
| | 7796 | A. | 15 31 | 11 35 27.7 |
| | 7815 | AA. | 18 46 | 51 37 5.5 |
| | 7855 | A. | 26 16 | 49 39 20.2 |
| | [9] | B. | 34 49 | 13 54 28.9 |
| | [8] | C. | 35 17 | 53 12 |
| | 7908 | AA. | 35 23 | 10 11 41.9 |
| | 7932 | A. | 38 39 | 41 10 45.4 |
| | 7945 | A. | 40 39 | 22 55 26.5 |
| | 7958 | A. | 44 7 | 23 57 38.0 |
| | 7984 | B. | 48 31 | 39 43 35.7 |
| | 7995 | B. | 51 5 | 49 4 56.6 |
| | 8034 | AA. | 22 58 41 | 14 32 56.9 |
| | 8059 | B. | 23 2 13 | 48 37 52.9 |
| | 8082 | A. | 6 58 | 48 44 23.7 |
| | 8128 | A. | 14 4 | 41 24 37.5 |
| | 8160 | A. | 19 17 | 22 43 57.4 |
| | 8177 | A. | 21 47 | 5 42 32.2 |
| | 8188 | B. | 24 24 | 57 52 35.3 |
| | 8233 | AA. | 33 41 | 4 57 54.2 |
| | 8268 | A. | 41 6 | 57 58 20.9 |
| | 8310 | A. | 48 18 | 56 49 18.9 |
| | 8331 | AA. | 53 3 | 6 11 16.8 |

[1] 112 Heis Ophiuchi.
[2] 14* Heis Lyræ.
[3] 26 Heis Lyræ.
[4] 179 Heis Draconis.
[5] 67 Heis Aquilæ (980).
[6] 30 Heis Delphini (1254).
[7] 194 Heis Cygni (1382).
[8] Piazzi XXII 186 (No. 1519).
[9] 30* Heis Lacertæ.

*Observations and computations for latitude of Fort Bliss, Tex.*

| Date. | Number of star. | Micrometer readings. | Level. |  | Half sum of declination. | Corrections. |  |  | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | N. | S. |  | Micr. and refr. | Level. | Merid. |  |
|  |  |  |  |  | ° ′ ″ | ′ ″ | ″ |  | ° ′ ″ |
| August 29, 1878.... | 6734 | 14.906 | 18.2 | 18.0 | 31 44 24.2 | + 1 2.9 | −2.6 | ........ | 31 45 24.5 |
|  | ........ | 12.882 | 13.4 | 22.0 |  |  |  |  |  |
|  | 6893 | — 6.058 | 8.8 | 29.6 | 31 34 6.9 | +11 32.6 | −8.1 | ........ | 31.4 |
|  | 6976 | 28.358 | 16.8 | 22.2 |  |  |  |  |  |
|  | 7062 | 15.471 | 18.2 | 21.4 | 31 42 42.3 | + 2 48.1 | +0.1 | ........ | 30.5 |
|  | 7085 | 40.798 | 16.0 | 23.6 |  |  |  |  |  |
|  | 7091 | 25.373 | 16.0 | 23.8 |  |  |  |  |  |
|  | 7173 | 21.799 | 23.2 | 16.8 |  |  |  |  |  |
|  | ........ | 19.212 | 14.0 | 25.2 | 31 45 33.7 | − 0 2.8 | −2.3 | ........ | 28.6 |
|  | 7345 | 19.123 | 22.2 | 18.4 |  |  |  |  |  |
|  | 7368 | 2.828 | 24.0 | 17.0 | 32 3 40.2 | −18 7.3 | +0.4 | ........ | 33.3 |
|  | 7399 | 37.836 | 17.8 | 23.4 |  |  |  |  |  |
|  | [7410 | 17.971 | 4.0 | 37.0] |  |  |  |  |  |
|  | 7474 | 3.448 | 6.0 | 35.0 | 31 29 25.4 | +16 10.8 | −7.4 | ........ | 28.8 |
|  | 7521 | 34.705 | 23.0 | 18.0 |  |  |  |  |  |
|  | 7555 | 15.453 | 10.0 | 30.8 | 31 49 19.1 | − 3 34.8 | −9.4 | ........ | 34.9 |
|  | 7561 | 22.367 | 15.4 | 24.8 |  |  |  |  |  |
|  | ........ | 19.843 | 23.0 | 18.2 | 31 43 19.3 | + 2 9.5 | +0.7 | ........ | 29.5 |
|  | 7627 | 24.013 | 19.4 | 22.0 |  |  |  |  |  |
|  | 7641 | 7.452 | 20.0 | 21.8 | 31 54 4.3 | − 8 29.7 | −1.9 | ........ | 32.7 |
|  | 7676 | 23.862 | 19.0 | 23.2 |  |  |  |  |  |
|  | 7723 | 10.546 | 26.4 | 15.4 | 31 36 15.4 | + 9 14.3 | −0.7 | ........ | 31 45 29.0 |
|  | 7749 | 28.393 | 14.4 | 27.8 |  |  |  |  |  |
|  | 7796* | 28.681 | 25.0 | 17.8 | 31 36 35.2 | + 7 42.2 | −2.4 | ........ | 31 44 [15.0] |
|  | 7815 | 13.800 | 13.4 | 28.2 |  |  |  |  |  |
|  | 7855 | 23.740 | 23.4 | 19.8 | 31 47 13.7 | − 1 48.7 | +4.4 | ........ | 31 45 29.4 |
|  | ........ | 20.241 | 26.6 | 16.0 |  |  |  |  |  |
|  | 7958 | 22.183 | 19.8 | 23.4 | 31 50 56.2 | − 5 23.4 | −1.9 | ........ | 30.9 |
|  | 7984 | 11.772 | 20.0 | 22.6 |  |  |  |  |  |
|  | 7995 | 8.096 | 15.0 | 27.4 | 31 41 20.0 | + 4 15.9 | −2.4 | ........ | 33.5 |
|  | 8034 | 15.134 | 20.8 | 21.0 |  |  |  |  |  |
|  | 8059 | 34.150 | 17.8 | 24.0 |  |  |  |  |  |
|  | 8082 | 27.876 | 19.0 | 22.8 |  |  |  |  |  |
|  | 8128 | 3.554 | 26.0 | 14.4 | 32 4 37.0 | −19 9.4 | +6.6 | ........ | 34.2 |
|  | 8160 | 40.560 | 25.6 | 16.0 |  |  |  |  |  |
|  | 8177 | 40.624 | 18.8 | 22.8 | 31 49 19.3 | − 3 47.0 | −2.1 | ........ | 30.2 |
|  | 8188 | 36.113 | 19.0 | 23.0 |  |  |  |  |  |
|  | 8268 | 30.521 | 20.2 | 21.8 |  |  |  |  |  |
|  | 8310 | 33.734 | ...... | ...... | 31 30 34.6 | +14 57.2 | 0. | ........ | 31.8 |
|  | 8331 | 4.847 | ...... | ...... |  |  |  |  |  |
| August 25, 1878.... | ........ | 16.762 | 24.2 | 29.8 | 31 46 40.0 | − 1 5.4 | −1.3 | ........ | 33.3 |
|  | 6387 | 18.868 | 27.8 | 26.4 |  |  |  |  |  |
|  | ........ | 34.494 | 34.4 | 19.8 | 32 1 6.3 | −15 56.2 | +21.7 | ........ | 31.8 |
|  | 6427 | 3.708 | 55 | —0.5 |  |  |  |  |  |
|  | 6607 | 27.794 | 22.8 | 32.8 | 31 53 34.6 | − 8 1.2 | − 4.0 | ........ | 29.4 |
|  | 6690 | 12.302 | 26.2 | 29.0 |  |  |  |  |  |
|  | 6833 | 13.971 | 18.2 | 38.0 | 31 39 26.3 | + 5 51.8 | +11.1 | ........ | 29.2 |
|  | 6847 | 25.296 | 55 | —0.5 |  |  |  |  |  |
|  | 6893 | 32.604 | 17.6 | 39.0 | 31 34 7.1 | +11 30.7 | − 7.4 | ........ | 30.4 |
|  | 6976 | 10.366 | 27.0 | 29.4 |  |  |  |  |  |
|  | 7271 | 29.246 | 22.4 | 33.4 | 31 39 19.7 | + 6 7.5 | + 2.6 | ........ | 31 45 29.8 |
|  | 7332 | 9.724 | 37.6 | 18.2 |  |  |  |  |  |
|  | 7365 | 25.106 | 37.6 | 18.4 |  |  |  |  |  |

*Some error; I cannot find what it is.

*Observations and computations for latitude of Fort Bliss, Tex.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. | | Half sum of declination. | Corrections. | | | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
| | | | N. | S. | | Micr. and refr. | Level. | Merid. | |
| | | | | | ° ′ ″ | ′ ″ | ″ | | ° ′ ″ |
| August 25, 1878 .... | 7410 | 18.463 | 32.6 | 23.8 | 31 32 59.7 | +12 33.1 | − 8.7 | ........ | 31 45 24.1 |
| | 7474 | 4.640 | 33.0 | 23.6 | | | | | |
| | 7521 | 35.796 | 10.0 | 47.2 | | | | | |
| | 7555 | 14.564 | 17.0 | 40.4 | 31 49 19.3 | − 3 45.5 | − 5.7 | ........ | 28.1 |
| | 7561 | 21.823 | 31.0 | 26.0 | | | | | |
| | ....... | 17.679 | 27.2 | 29.8 | 31 43 19.6 | + 2 12.0 | − 3.7 | ........ | 27.9 |
| | 7627 | 21.930 | 24.0 | 33.2 | | | | | |
| | 7641 | 9.893 | 33.0 | 25.2 | 31 54 4.5 | − 8 41.4 | + 9.9 | ........ | 33.0 |
| | 7676 | 26.681 | 41.4 | 17.2 | | | | | |
| | 7958 | 20.596 | 27.2 | 32.8 | 31 50 56.4 | − 5 24.0 | − 6.1 | ........ | 36.3 |
| | 7984 | 10.165 | 23.0 | 37.2 | | | | | |
| | 7995 | 9.061 | 25.0 | 35.6 | 31 44 8.2 | + 1 20.8 | + 5.5 | ........ | 34.5 |
| | 8034 | 16.271 | 30.2 | 30.2 | | | | | |
| | 8062 | 28.650 | 53.0 | 7.0 | | | | | |
| August 27, 1878 .... | 6599 | 33.185 | 28.4 | 23.8 | 31 58 37.0 | −18 7.3 | − 0.9 | ........ | 28.8 |
| | 6637 | 7.836 | 22.6 | 30.0 | | | | | |
| | 6667 | 7.830 | 25.8 | 26.8 | 31 53 35.0 | − 8 10.1 | +11.1 | ........ | 36.0 |
| | 6690 | 23.610 | 44.0 | 7.2 | | | | | |
| | 6734 | 18.088 | 26.0 | 26.4 | 31 44 24.7 | + 1 0.0 | + 9.8 | ........ | 34.5 |
| | ....... | 20.020 | 42.2 | 10.2 | | | | | |
| | 6833 | 15.064 | 24.8 | 28.0 | 31 39 26.7 | + 5 59.4 | + 4.7 | ........ | 30.8 |
| | 6847 | 26.634 | 35.4 | 16.8 | | | | | |
| | 6893 | 32.266 | 23.8 | 29.8 | 31 34 7.5 | +11 21.7 | + 2.3 | ........ | 31.5 |
| | 6976 | 10.317 | 33.2 | 19.8 | | | | | |
| | *7062 | 20.822 | 35.0 | 19.0 | 31 36 28.5 | + 9 7.5 | − 1.9 | ........ | 34.1 |
| | *7085 | 44.208 | 34.4 | 19.6 | | | | | |
| | [*7091 | 30.567] | ...... | ...... | | | | | |
| | 7107 | 4.563 | 4.2 | 50.0 | | | | | |
| | 7173 | 27.207 | 28.8 | 26.0 | | | | | |
| | 7213 | 21.463 | 34.8 | 19.8 | 31 49 24.9 | − 8 58.4 | + 5.6 | ........ | 32.1 |
| | 7256 | 13.786 | 29.0 | 26.0 | | | | | |
| | ....... | 17.156 | 23.4 | 31.8 | 31 43 52.2 | + 1 43.4 | − 6.1 | ........ | 29.5 |
| | 7301 | 10.535 | 22.8 | 32.4 | | | | | |
| | 7345 | 17.119 | 21.2 | 34.2 | | | | | |
| August 29, 1878 .... | 6203 | 3.140 | 35.4 | 37.0 | 31 58 6.7 | −12 32.9 | − 3.6 | ........ | 30.2 |
| | 6235 | 33.055 | 32.2 | 40.0 | | | | | |
| | 6251 | 21.707 | 30.0 | 42.2 | | | | | |
| | 6268 | 10.607 | 29.6 | 43.2 | 31 37 0.4 | + 8 32.6 | − 5.0 | ........ | 28.0 |
| | 6300 | 27.111 | 35.0 | 37.6 | | | | | |
| | 6348 | 18.472 | 28.0 | 18.8 | 31 46 11.6 | − 0 27.0 | − 6.9 | ........ | [37.7] |
| | ....... | 19.341 | 7.0 | 38.4 | | | | | |
| | ....... | 20.458 | 24.0 | 22.3 | 31 46 40.5 | − 1 3.5 | − 3.9 | ........ | 33.1 |
| | 6387 | 18.413 | 15.8 | 30.2 | | | | | |
| | ....... | 3.765 | 28.0 | 18.2 | 32 1 6.9 | −15 41.1 | − 3.1 | ........ | 22.7 |
| | 6427 | 34.063 | 13.2 | 33.0 | | | | | |
| | 6463 | 13.063 | 18.6 | 27.8 | 31 38 44.8 | + 6 54.6 | − 7.9 | ........ | 31.5 |
| | 6460 | 26.431 | 15.0 | 31.4 | | | | | |
| | 6476 | 16.832 | 16.6 | 29.6 | 31 48 32.0 | − 3 0.8 | − 5.6 | ........ | 25.6 |
| | †6487 | 18.652 | 20.8 | 25.8 | | | | | |
| | ....... | 34.612 | 19.8 | 26.4 | 32 1 33.3 | −15 58.2 | − 3.2 | ....... | 31.9 |
| | 6528 | 3.763 | 16.4 | 30.0 | | | | | |
| | 6553 | 20.624 | 14.0 | 32.0 | 31 41 54.7 | + 3 38.2 | − 3.5 | ........ | 31 45 29.4 |
| | 6571 | 13.598 | 26.4 | 19.8 | | | | | |

*7085 should read $46^{r}$. The instrument probably jumped before 7091; this star has been omitted.
†Probably 22.652.

*Observations and computations for latitude of Fort Bliss, Tex.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. |  | Half sum of declination. | Corrections. |  |  | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | N. | S. |  | Micr. and refr. | Level. | Merid. |  |
|  |  |  |  |  | ° ′ ″ | ′ ″ | ″ |  | ° ′ ″ |
| August 29, 1878 .... | 6599 | 33.435 | 40.0 | 6.4 | 31 58 37.3 | −13 11.4 | − 2.0 | ........ | 31 45 23.9 |
|  | 6637 | 7.954 | 3.4 | 43.4 |  |  |  |  |  |
|  | 6667 | 10.314 | 28.4 | 18.2 | 31 53 35.3 | − 7 59.7 | − 2.4 | ........ | 33.2 |
|  | 6690 | 25.768 | 14.0 | 31.8 |  |  |  |  |  |
|  | 6979 | 10.460 | 16.8 | 28.8 | 31 39 44.5 | + 5 52.5 | − 5.0 | ........ | 32.0 |
|  | 7008 | 21.810 | 21.2 | 25.4 |  |  |  |  |  |
|  | 7062 | 24.171 | 22.4 | 24.4 | 31 37 44.6 | + 7 51.8 | − 5.0 | ........ | 31.4 |
|  | 7091 | 34.037 | 21.8 | 25.4 |  |  |  |  |  |
|  | 7107 | 8.093 | 15.8 | 30.2 |  |  |  |  |  |
|  | 7121 | 3.275 | 15.6 | 30.2 |  |  |  |  |  |
|  | 7173 | 30.374 | 18.0 | 29.0 |  |  |  |  |  |
|  | 7213 | 21.539 | 18.0 | 29.0 | 31 49 25.4 | − 3 54.2 | − 4.6 | ........ | 26.6 |
|  | 7256 | 13.999 | 22.0 | 25.8 |  |  |  |  |  |
|  | (*) | *13.067 | 21.8 | 26.2 | 31 43 52.8 | + 1 42.1 | − 3.1 | ........ | 31.8 |
|  | 7301 | 11.524 | 21.0 | 26.8 |  |  |  |  |  |
|  | *7345 | 18.035 | †26.2 | 26.8 |  |  |  |  |  |
|  | 7555 | 22.988 | 32.4 | 16.6 | 31 49 20.3 | − 3 45.5 | − 8.1 | ....... | 26.7 |
|  | 7561 | 15.728 | 3.8 | 45.6 |  |  |  |  |  |
|  | 7641 | 8.583 | 16.8 | 33.0 | 31 54 5.7 | − 8 30.4 | − 4.4 | ........ | 30.9 |
|  | 7676 | 25.016 | 25.6 | 23.6 |  |  |  |  |  |
|  | 7723 | 9.362 | 27.2 | 21.6 | 31 36 16.6 | + 9 20.4 | − 7.9 | ........ | 29.1 |
|  | 7749 | 27.404 | 9.0 | 39.8 |  |  |  |  |  |
|  | 7796 | 27.435 | 20.6 | 28.4 | 31 36 36.5 | + 8 58.8 | − 7.3 | ........ | 28.0 |
|  | 7815 | 10.089 | 16.2 | 31.8 |  |  |  |  |  |
|  | 7958 | 17.051 | 24.2 | 25.0 | 31 50 57.5 | − 5 14.2 | − 6.2 | ........ | 37.1 |
|  | 7984 | 27.166 | 14.8 | 34.0 |  |  |  |  |  |
|  | 7995 | 28.533 | 31.0 | 18.8 | 31 44 9.2 | + 1 23.2 | − 2.4 | ........ | 30.0 |
|  | 8034 | 21.113 | 23.4 | 26.2 |  |  |  |  |  |
|  | 8082 | 8.338 | 13.2 | 35.4 |  |  |  |  |  |
|  | 8128 | 44.745 | 32.6 | 17.6 | 32 4 38.3 | −19 16.1 | + 8.1 | ........ | 30.2 |
|  | 8160 | 7.523 | 30.4 | 19.4 |  |  |  |  |  |
|  | 8177 | 3.926 | 16.8 | 33.6 | 31 38 11.1 | + 7 26.1 | − 6.4 | ........ | 30.8 |
|  | 8188 | 8.303 | 23.0 | 27.2 |  |  |  |  |  |
|  | 8233 | 46.945 | 16.8 | 34.0 |  |  |  |  |  |
|  | 8268 | 13.845 | 24.0 | 26.8 |  |  |  |  |  |
|  | 8310 | 6.926 | 24.2 | 26.2 | 31 30 35.6 | +15 1.9 | − 5.8 | ........ | 31.9 |
|  | 8331 | 35.964 | 17.2 | 34.0 |  |  |  |  |  |
| August 30, 1878 .... | 6143 | 10.976 | 27.4 | 12.6 | 31 54 5.2 | − 8 36.9 | + 2.9 | ........ | 31.2 |
|  | 6185 | 27.619 | 16.8 | 22.2 |  |  |  |  |  |
|  | 6203 | 42.846 | 7.4 | 32.8 | 31 58 6.8 | −12 33.5 | + 3.9 | ........ | 37.2 |
|  | 6231 | 12.851 | 42.0 | −2.6 |  |  |  |  |  |
|  | 6251 | 24.319 | 35.8 | 4.2 |  |  |  |  |  |
|  | 6268 | 27.459 | 16.4 | 23.6 | 31 37 0.6 | + 8 27.6 | + 2.7 | ........ | 30.9 |
|  | 6300 | 11.116 | 28.0 | 12.0 |  |  |  |  |  |
|  | 6348 | 17.623 | 15.6 | 23.0 | 31 46 11.7 | − 0 33.1 | + 4.9 | ........ | 43.5 |
|  | ........ | 16.558 | 31.3 | 8.0 |  |  |  |  |  |
|  | ....... | 13.117 | 21.4 | 18.6 | 32 1 33.5 | −16 1.8 | +12.0 | ........ | 43.7 |
|  | 6528 | 44.084 | 38.0 | 2.0 |  |  |  |  |  |
|  | 6553 | 26.903 | 23.0 | 17.8 | 31 41 54.9 | + 3 28.1 | + 5.1 | ........ | 28.1 |
|  | 6571 | 33.607 | 25.8 | 14.6 |  |  |  |  |  |
|  | 6599 | 15.767 | 20.2 | 20.8 | 31 58 37.4 | −13 5.3 | + 7.3 | ........ | 39.4 |
|  | 6637 | 41.051 | 32.8 | 8.6 |  |  |  |  |  |
|  | 6667 | 38.150 | 23.4 | 18.0 | 31 53 35.5 | − 8 4.9 | + 3.7 | ........ | 31 45 34.3 |
|  | 6690 | 22.537 | 24.0 | 17.6 |  |  |  |  |  |

*Read 18.067.

† 21.2 26.8 seems the correct level reading.

*Observations and computations for latitude of Fort Bliss, Tex.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. | | Half sum of declination. | Corrections. | | | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
| | | | N. | S. | | Micr. and refr. | Level. | Merid. | |
| | | | | | ° ′ ″ | ′ ″ | ″ | | ° ′ ″ |
| **August 30, 1878** .... | 6709 | 16.707 | 23.2 | 18.0 | 31 58 15.3 | −12 45.0 | + 3.6 | ........ | 31 45 33.9 |
| | 6731 | 41.338 | 24.0 | 17.6 | | | | | |
| | 6748 | 19.363 | 13.4 | 28.2 | 31 37 17.2 | + 8 9.6 | + 4.0 | ........ | 30.8 |
| | 6802 | 35.127 | 35.0 | 7.4 | | | | | |
| | 6833 | 33.096 | 20.8 | 22.0 | 31 39 27.2 | + 6 2.4 | + 0.9 | ........ | 30.5 |
| | 6847 | 21.427 | 23.2 | 19.2 | | | | | |
| | *6893 | 14.673 | 20.0 | 22.4 | 31 34 8.1 | +11 17.5 | + 5.0 | ........ | 30.6 |
| | 6976 | 16.485 | 30.0 | 11.6 | | | | | |
| | 6979 | 34.464 | 9.0 | 33.4 | 31 39 44.7 | + 5 53.8 | − 5.9 | ........ | 32.6 |
| | 7008 | 23,072 | 23.8 | 18.4 | | | | | |
| | 7062 | 19.178 | 18.6 | 24.0 | 31 36 12.4 | + 9 14.3 | + 3.0 | ........ | 29.7 |
| | 7091 | 9.280 | 17.8 | 25.0 | | | | | |
| | 7107 | 34.910 | 29.8 | 13.4 | | | | | |
| | 7121 | 39.675 | 29.2 | 13.8 | | | | | |
| | 7160 | †39.992 | 29.0 | 13.6 | | | | | |
| | 7173 | 12.723 | 29.4 | 13.2 | | | | | |
| | 7213 | 26.964 | 21.0 | 22.8 | 31 49 25.6 | − 3 55.0 | + 2.4 | ........ | 33.0 |
| | 7256 | 34.530 | 27.0 | 17.6 | | | | | |
| | ........ | 29.419 | 32.0 | 12.6 | 31 43 52.9 | + 1 35.6 | + 2.4 | ........ | 30.9 |
| | 7301 | ‡30.774 | 16.8 | 27.8 | | | | | |
| | 7345 | 29.220 | 16.0 | 28.6 | | | | | |
| | 7368 | 6.371 | 27.6 | 18.0 | 32 3 41.7 | −18 9.9 | + 9.4 | ........ | 41.2 |
| | 7399 | 41.461 | 33.0 | 12.4 | | | | | |
| | 7555 | 15.972 | 15.8 | 29.8 | 31 49 20.5 | − 3 49.9 | − 0.6 | ........ | 30.0 |
| | 7561 | 23.374 | 20.0 | 16.8 | | | | | |
| | 7688 | 19.093 | 19.0 | 26.6 | 31 33 58.1 | +11 29.8 | + 3.1 | ....... | 31.0 |
| | 7700 | 41.802 | 31.0 | 13.4 | | | | | |
| | 7723 | 38.558 | 18.2 | 27.4 | 31 36 16.8 | + 9 11.8 | + 2.0 | ........ | 30.6 |
| | 7749 | 20.791 | 30.6 | 15.0 | | | | | |
| | 7796 | 18.772 | 21.6 | 24.0 | 31 36 36.8 | + 8 48.0 | + 5.4 | ........ | 30.2 |
| | 7815 | 35.773 | 32.8 | 13.0 | | | | | |
| | 7932 | 6.080 | 25.8 | 20.2 | 32 3 26.8 | −17 53.2 | + 9.8 | ........ | 43.4 |
| | 7945 | 40.632 | 36.0 | 10.0 | | | | | |
| | 7958 | 31.159 | 27.6 | 18.4 | 31 50 57.8 | − 5 23.6 | + 1.0 | ........ | 35.2 |
| | 7984 | 20.740 | 20.0 | 26.0 | | | | | |
| | 7995 | 19.168 | 19.0 | 27.2 | 31 41 21.6 | + 4 6.9 | + 4.3 | ........ | 32.8 |
| | 8034 | 26.526 | 40.4 | 6.4 | | | | | |
| | 8059 | §44.247 | 11.2 | 35.2 | | | | | |
| | 8082 | 39.013 | 9.2 | 37.8 | | | | | |
| | 8128 | 5.160 | 19.2 | 27.6 | 32 4 38.6 | −19 5.7 | − 0.5 | ........ | 32.4 |
| | 8160 | 42.048 | 26.8 | 20.0 | | | | | |
| | 8177 | ‖46.160 | 16.0 | 30.0 | 31 49 20.8 | − 3 47.1 | + 0.4 | ........ | ? 34.1 |
| | 8188 | 40.081 | 31.0 | 15.0 | | | | | |
| | 8268 | 34.527 | 30.2 | 15.8 | | | | | |
| | 8310 | 43.543 | 27.0 | 20.0 | 31 30 36.0 | +14 51.4 | + 3.5 | ........ | 30.9 |
| | 8331 | 14.843 | 25.8 | 21.4 | | | | | |
| **September 1, 1878** .. | 6203 | 39.107 | 32.0 | 25.8 | 31 58 7.0 | −12 33.1 | − 0.2 | ........ | 33.7 |
| | 6231 | 9.188 | 26.4 | 31.4 | | | | | |
| | 6251 | 20.534 | 24.4 | 33.2 | | | | | |
| | 6268 | 28.208 | 18.0 | 40.2 | 31. 37 0.8 | + 8 39.2 | − 6.3 | ........ | 33.7 |
| | 6300 | 11.491 | 29.8 | 28.0 | | | | | |
| | 6463 | 20.643 | 21.2 | 8.0 | 31 38 45.1 | + 6 40.1 | + 6.4 | ........ | 31 45 31.6 |
| | 6460 | 33.525 | 18.6 | 11.2 | | | | | |

*Micr. diff. $20^{r}$. in error. †$40^{r}$.992. ‡$35^{r}$.774. §$45^{r}$.247. ‖$44^{r}$.616. ?

*Observations and computations for latitude of Fort Bliss, Tex.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. | | Half sum of declination. | Corrections. | | | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
| | | | N. | S. | | Micr. and refr. | Level. | Merid. | |
| | | | | | ° ′ ″ | ′ ″ | ″ | | ° ′ ″ |
| September 1, 1878 .. | 6476 | 25.253 | 19.4 | 10.4 | 31 48 32.5 | − 3 3.3 | + 4.7 | ........ | 31 45 33.94 |
| | 6487 | 31.154 | 18.0 | 11.8 | | | | | |
| | ........ | 40.637 | 12.0 | 17.8 | 32 1 33.8 | −15 53.4 | − 5.1 | ........ | 35.3 |
| | 6528 | 9.943 | 9.8 | 20.6 | | | | | |
| | 6553 | 26.901 | *10.0 | 11.0 | 31 41 55.2 | + 3 29.8 | + 4.5 | ........ | 29.5 |
| | 6571 | 20.145 | 18.0 | 12.4 | | | | | |
| | 6599 | 40.473 | 25.4 | 5.8 | 31 58 37.7 | −13 19.3 | +14.0 | ........ | 32.4 |
| | 6637 | 14.739 | 28.4 | 3.0 | | | | | |
| | 6667 | 17.772 | 21.4 | 10.0 | 31 53 35.8 | − 8 8.5 | + 5.5 | ........ | 32.8 |
| | 6690 | 33.500 | 19.0 | 12.6 | | | | | |
| | 6709 | †18.087 | 28.0 | 3.6 | 31 58 15.6 | −12 55.2 | + 7.0 | ........ | 27.4 |
| | 6731 | 13.128 | 15.0 | 16.8 | | | | | |
| September 2, 1878 .. | ........ | ‡25.092 | 25.4 | 17.0 | 31 43 53.6 | + 1 27.6 | +10.5 | ........ | 31.7 |
| | 7301 | 32.166 | 35.0 | 6.8 | | | | | |
| | 7345 | 25.658 | 32.0 | 9.2 | | | | | |
| | 7474 | 11.832 | 29.0 | 13.0 | 31 29 27.6 | +15 50.8 | + 9.4 | ........ | 27.8 |
| | 7521 | 42.444 | 28.4 | 14.2 | | | | | |
| | 7555 | 21.892 | 16.2 | 26.6 | 31 49 21.2 | − 3 39.7 | − 8.4 | ........ | 33.1 |
| | 7561 | 28.964 | 13.0 | 29.8 | | | | | |
| | ........ | 24.355 | 25.6 | 17.8 | 31 43 21.6 | + 2 7.4 | + 0.4 | ........ | 29.4 |
| | 7627 | 28.456 | 16.0 | 22.4 | | | | | |
| | 7641 | 16.064 | 23.8 | 19.8 | 31 54 6.5 | − 8 35.2 | + 2.0 | ........ | 33.3 |
| | 7676 | 32.651 | 23.0 | 20.6 | | | | | |
| | §7688 | 26.112 | 23.6 | 18.8 | 31 33 58.8 | +11 34.6 | − 1.7 | ........ | 31.7 |
| | 7700 | 38.474 | 16.8 | 27.0 | | | | | |
| | 7723 | 34.603 | 18.2 | 25.2 | 31 36 17.4 | + 9 15.2 | − 3.1 | ........ | 29.5 |
| | 7749 | 16.729 | 20.4 | 23.4 | | | | | |
| | ‖7796 | 26.702 | 23.4 | 20.6 | 31 36 37.5 | + 8 54.2 | − 2.9 | ........ | 28.8 |
| | 7815 | 33.901 | 16.0 | 28.0 | | | | | |
| | 7855 | 20.295 | 12.0 | 32.0 | 31 47 16.0 | − 1 43.7 | − 0.8 | ........ | 31.5 |
| | 7912 | 23.633 | 30.8 | 13.4 | | | | | |
| | 7932 | 40.050 | 18.2 | 26.4 | 32 3 27.6 | −17 54.2 | − 6.7 | ........ | 26.7 |
| | 7945 | 5.465 | 15.6 | 29.0 | | | | | |
| | 7958 | 22.471 | 24.4 | 20.4 | 31 50 58.6 | − 5 21.3 | + 0.5 | ........ | 37.8 |
| | 7984 | 32.815 | 21.4 | 23.8 | | | | | |
| | 7995 | 35.549 | 28.4 | 16.6 | 31 41 22.4 | + 4 10.6 | − 2.6 | ........ | 30.4 |
| | 8034 | 28.300 | 8.0 | 37.6 | | | | | |
| | 8059 | 9.430 | 35.0 | 10.0 | | | | | |
| | 8082 | 15.718 | 36.2 | 9.4 | | | | | |
| | 8128 | 44.621 | 26.0 | 19.8 | 32 4 30.3 | −19 3.1 | + 6.4 | ........ | 42.6 |
| | 8160 | 7.818 | 30.2 | 15.8 | | | | | |
| | 8177 | 4.008 | 16.6 | 29.2 | 31 38 12.1 | + 7 19.6 | − 2.3 | ........ | 29.4 |
| | 8188 | 8.590 | 26.6 | 19.4 | | | | | |
| | 8233 | 47.043 | 16.2 | 29.6 | | | | | |
| | 8268 | 14.156 | 25.0 | 20.8 | | | | | |
| | ¶8310 | 9.909 | 35.0 | 11.8 | 31 30 36.7 | +13 51.8 | ........ | ........ | ............ |
| | 8331 | 36.688 | 39.6 | 36.4 | | | | | |
| September 4, 1878 .. | 6348 | 26.153 | 20.4 | 16.0 | 31 46 12.2 | − 0 26.5 | − 8.4 | ........ | [37.3] |
| | ........ | 25.301 | 2.6 | 34.0 | | | | | |
| | (**) | 22.712 | 18.8 | 18.0 | 31 46 41.2 | − 1 4.8 | − 2.5 | ........ | 33.9 |
| | 6387 | 25.797 | 13.6 | 22.4 | | | | | |
| | ........ | 41.415 | 24.4 | 12.2 | 32 1 7.7 | −15 38.8 | − 0.3 | ........ | 31 45 28.6 |
| | 6427 | 11.189 | 11.6 | 24.8 | | | | | |

* Should read 20.0 11.0. † $38^{r}$.087. ‡ $26^{r}$.092. § Diff. $22^{r}$.362, not $12^{r}$.362. ‖ Diff. $17^{r}$.199, not $7^{r}$.199.
¶ Level unintelligible. ** Diff. $2^{r}$.085 instead of $3^{r}$.085.

*Observations and computations for latitude of Fort Bliss, Tex.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. | | Half sum of declination. | Corrections. | | | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
| | | | N. | S. | | Micr. and refr. | Level. | Merid. | |
| | | | | | ° ′ ″ | ′ ″ | ″ | | ° ′ ″ |
| September 4, 1878 .. | 6463 | 30. 863 | 18. 8 | 18. 4 | 31 38 45. 5 | + 6 50. 6 | − 2. 3 | ........ | 31 45 33. 8 |
| | 6460 | 17. 642 | 14. 0 | 21. 8 | | | | | |
| | 6476 | 27. 337 | 4. 4 | 32. 6 | 31 48 32. 8 | − 3 6. 0 | − 2. 2 | ....... | 24. 6 |
| | 6487 | 21. 347 | 29. 0 | 8. 0 | | | | | |
| | ........ | 9. 135 | 15. 8 | 21. 6 | 32 1 34. 2 | −15 57. 7 | + 2. 7 | ........ | 39. 2 |
| | 6528 | 39. 969 | 25. 8 | 11. 4 | | | | | |
| | 6553 | 23. 695 | 20. 4 | 16. 6 | 31 41 55. 6 | + 3 36. 1 | − 5. 5 | ........ | 26. 2 |
| | 6571 | 30. 653 | 7. 8 | 29. 4 | | | | | |
| | 6599 | 11. 453 | 15. 8 | 21. 8 | 31 58 38. 1 | −13 7. 2 | + 1. 7 | ........ | 32. 6 |
| | 6637 | 36. 800 | 24. 4 | 13. 0 | | | | | |
| | *6667 | 30. 961 | 30. 0 | 7. 2 | 31 53 36. 3 | − 8 4. 5 | − 4. 9 | ........ | 26. 9 |
| | 6690 | 19. 362 | −0. 6 | 38. 0 | | | | | |
| | †6709 | 13. 266 | 24. 0 | 13. 6 | 31 58 16. 1 | −12 43. 6 | − 2. 2 | ........ | 30. 3 |
| | 6731 | 27. 852 | 10. 0 | 27. 4 | | | | | |
| | ‡6833 | 22. 381 | 27. 8 | 9. 8 | 31 39 28. 0 | + 6 5. 7 | +22. 4 | ........ | [?56. 1] |
| | 6847 | 24. 155 | 48. 2 | −6. | | | | | |
| | 7091 | 41. 082 | 18. 0 | 21. 0 | 31 33 40. 3 | +11 53. 8 | − 2. 8 | ........ | 31. 3 |
| | 7107 | 15. 260 | 16. 0 | 22. 4 | | | | | |
| | 7121 | 10. 460 | 16. 0 | 22. 0 | | | | | |
| | 7160 | 9. 229 | 16. 0 | 22. 0 | | | | | |
| | 7173 | 37. 460 | 16. 2 | 21. 6 | | | | | |
| | 7213 | 27. 919 | 14. 8 | 23. 4 | 31 49 26. 7 | − 3 53. 6 | − 2. 9 | ........ | 30. 2 |
| | 7256 | 20. 398 | 19. 2 | 20. 0 | | | | | |
| | ........ | 24. 831 | 12. 4 | 27. 0 | 31 43 54. 0 | + 1 38. 3 | + 1. 6 | ........ | 33. 9 |
| | 7301 | 18. 375 | 29. 6 | 10. 0 | | | | | |
| | 7345 | 24. 956 | 29. 4 | 9. 8 | | | | | |
| | 7410 | 25. 488 | 14. 0 | 24. 8 | 31 33 2. 1 | +12 29. 8 | − 3. 0 | ........ | 28. 9 |
| | 7474 | 39. 246 | 11. 4 | 27. 6 | | | | | |
| | 7521 | 8. 225 | 21. 4 | 17. 6 | | | | | |
| | 7555 | 29. 016 | 15. 4 | 22. 6 | 31 49 21. 6 | − 3 46. 1 | − 4. 7 | ........ | 30. 8 |
| | 7561 | 21. 736 | 15. 6 | 23. 4 | | | | | |
| | ........ | 24. 953 | 25. 6 | 13. 4 | 31 43 22. 2 | + 2 10. 4 | + 4. 7 | ........ | 37. 3 |
| | 7627 | 20. 754 | 20. 8 | 18. 0 | | | | | |
| | 7641 | 33. 872 | 14. 4 | 24. 8 | 31 54 7. 0 | − 8 33. 6 | − 3. 3 | ........ | 30. 1 |
| | 7676 | 17. 336 | 19. 4 | 19. 6 | | | | | |
| | 7688 | 35. 717 | 9. 2 | 29. 8 | 31 33 59. 2 | +11 38. 3 | − 5. 8 | ........ | 31. 7 |
| | 7700 | 13. 236 | 20. 6 | 18. 8 | | | | | |
| | 7723 | 16. 235 | 18. 0 | 21. 0 | 31 36 17. 8 | + 9 15. 9 | − 5. 3 | ........ | 28. 4 |
| | 7749 | 34. 132 | 12. 6 | 26. 8 | | | | | |
| | 7796 | 35. 115 | 12. 0 | 27. 4 | 31 36 38. 0 | + 8 51. 5 | + 2. 0 | ........ | 31. 5 |
| | 7815 | 18. 003 | 30. 8 | 9. 0 | | | | | |
| | 7855 | 29. 502 | 34. 0 | 5. 6 | 31 47 16. 5 | − 1 53. 9 | +10. 6 | ....... | 33. 2 |
| | ........ | 25. 834 | 22. 6 | 16. 8 | | | | | |
| | 7932 | 10. 532 | 16. 8 | 23. 2 | 32 3 28. 1 | −17 56. 8 | + 1. 0 | ........ | 32. 3 |
| | 7945 | 45. 202 | 24. 6 | 15. 0 | | | | | |
| | 7958 | 29. 465 | 18. 6 | 21. 0 | 31 50 59. 1 | − 5 22. 2 | − 1. 2 | ........ | 35. 7 |
| | 7984 | 19. 093 | 19. 2 | 20. 6 | | | | | |
| | 7995 | 15. 634 | 31. 0 | 8. 8 | 31 41 22. 9 | + 4 13. 9 | − 6. 4 | ........ | 30. 4 |
| | §8034 | 22. 933 | 54. 0 | 34. 4 | | | | | |
| | 8059 | 41. 967 | 21. 4 | 18. 6 | | | | | |
| | 8082 | 35. 723 | 21. 6 | 18. 6 | | | | | |
| | 8128 | 6. 377 | 14. 0 | 26. 2 | 32 4 39. 8 | −19 7. 7 | + 2. 7 | ........ | 31 45 34. 8 |
| | 8160 | 43. 329 | 30. 4 | 9. 6 | | | | | |

* Diff. $15^{r}.599$. † Diff. $24^{r}.586$. ‡ Diff. $11^{r}.774$. ? § Level should read, 5.4 34.4.

*Observations and computations for latitude of Fort Bliss, Tex.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. |  | Half sum of declination. | Corrections. |  |  | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | N. | S. |  | Micr. and refr. | Level. | Merid. |  |
|  |  |  |  |  | ° ′ ″ | ′ ″ | ″ |  | ° ′ ″ |
| September 4, 1878 .. | 8177 | 46. 881 | 23. 2 | 17. 0 | 31 38 12. 5 | + 7 19. 2 | − 1. 1 | ........ | 31 45 30. 6 |
|  | 8188 | 42. 248 | 48. 0 | 22. 2 |  |  |  |  |  |
|  | 8233 | 3. 812 | 21. 4 | 19. 2 |  |  |  |  |  |
|  | 8268 | 36. 727 | 15. 0 | 26. 0 |  |  |  |  |  |
|  | *8310 | 20. 415 | 17. 4 | 23. 8 | 31 30 37. 1 | +14 53. 8 | − 2. 4 | ........ | 31 45 28. 5 |
|  | 8331 | 11. 638 | 19. 6 | 21. 0 |  |  |  |  |  |

* Diff. $28^{r}.777$.

*Discussion of latitude—Fort Bliss.*

| No. of combinations. | No. of observations. | No. of stars. | Latitude. | Correction to micrometer. | Date rejected. | No. of combinations. | No. of observations. | No. of stars. | Latitude. | Correction to micrometer. | Date rejected. |
|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | ° ′ ″ | ″ |  |  |  |  | ° ′ ″ | ″ |  |
| 1.... | 1 | 2 | 31 45 31. 2 | −0. 60 |  | 20... | 5 | 7 | 31 45 31. 40 | +0. 57 |  |
| 2.... | 3 | 3 | 33. 70 | −0. 88 |  | 21... | 4 | 2 | 30. 48 | −0. 28 |  |
| 3.... | 3 | 2 | 30. 87 | +0. 60 |  | 22 .. | 1 | 3 | 29. 8 | +0. 43 |  |
| 4.... | 3 | 2 | [39. 50] | −0. 04 |  | 23... | 6 | 3 | 31. 07 | +0. 09 |  |
| 5.... | 3 | 2 | 33. 43 | −0. 08 |  | 24... | 1 | 2 | 33. 3 | −1. 27 | Aug. 30. |
| 6.... | 2 | 2 | 30. 20 | −1. 11 | Aug. 29 | 25... | 4 | 3 | 27. 40 | +1. 00 |  |
| 7.... | 3 | 2 | 32. 30 | +0. 48 |  | 26... | 6 | 2 | 30. 72 | −0. 26 |  |
| 8.... | 3 | 2 | 28. 37 | −0. 21 |  | 27... | 4 | 2 | 31. 37 | +0. 15 |  |
| 9.... | 3 | 2 | 35. 47 | −1. 12 | Aug. 30 | 28... | 5 | 2 | 32. 00 | −0. 60 |  |
| 10.... | 4 | 2 | 28. 30 | +0. 24 |  | 29... | 3 | 2 | 31. 47 | +0. 81 |  |
| 11.... | 5 | 2 | 31. 42 | −0. 92 |  | 30... | 5 | 2 | 29. 32 | +0. 65 |  |
| 12.... | 6 | 2 | 32. 52 | −0. 57 |  | 31... | 4 | 2 | 29. 62 | +0. 62 | Aug. 24. |
| 13.... | 3 | 2 | 30. 53 | −0. 90 |  | 32... | 3 | 2 | 31. 37 | −0. 13 |  |
| 14.... | 2 | 2 | 29. 50 | +0. 07 |  | 33 .. | 2 | 2 | 29. 50 | −1. 25 | Aug. 30. |
| 15.... | 1 | 2 | 30. 8 | +0. 57 |  | 34 .. | 6 | 2 | 33. 83 | −0. 38 |  |
| 16.... | (*) | (*) | ........ | ........ |  | 35... | 6 | 4 | 31. 93 | +0. 22 |  |
| 17.... | 3 | 2 | 30. 17 | +0. 41 | Sept. 4 | 36... | 4 | 2 | 32. 80 | −1. 34 | Sept. 2. |
| 18.... | 4 | 2 | 30. 98 | +0. 80 |  | 37... | 5 | 4 | 31. 06 | +0. 20 |  |
| 19.... | 2 | 2 | 32. 30 | +0. 34 |  | 38... | 5 | 2 | 30. 78 | +1. 04 |  |

Pair 4; place of star [1] uncertain.

* Not observed.

**Final latitude, 31° 45′ 31″.14 ± 0″.17.**

NOTE.—The bell-tower of the cathedral in El Paso, Mexico, and the boundary monument on the righ bank of the Rio Grande, five miles above El Paso on the parallel of 31° 47′, were connected with the Fort Bliss astronomical monument by triangulation.

The same points were located by the Mexican Boundary Commission in 1852 and 1855.

Their longitudes were derived from that of the observatory at Frontera, determined by Maj. W. H. Emory from observations of moon culminations on 38 nights during 4 lunations? and from that of the observatory at San Elceario, determined by Lieut. W. F. Smith from similar observations on 32 nights during 5 lunations; each corrected by half the difference ($0^{s}.645$) between the astronomical difference ($1^{m}\ 8^{s}.59$) and the assumed absolute difference of longitude ($1^{m}\ 7^{s}.30$), as determined by 56 signal flashes of gunpowder simultaneously observed at the two places during 4 nights, thus:

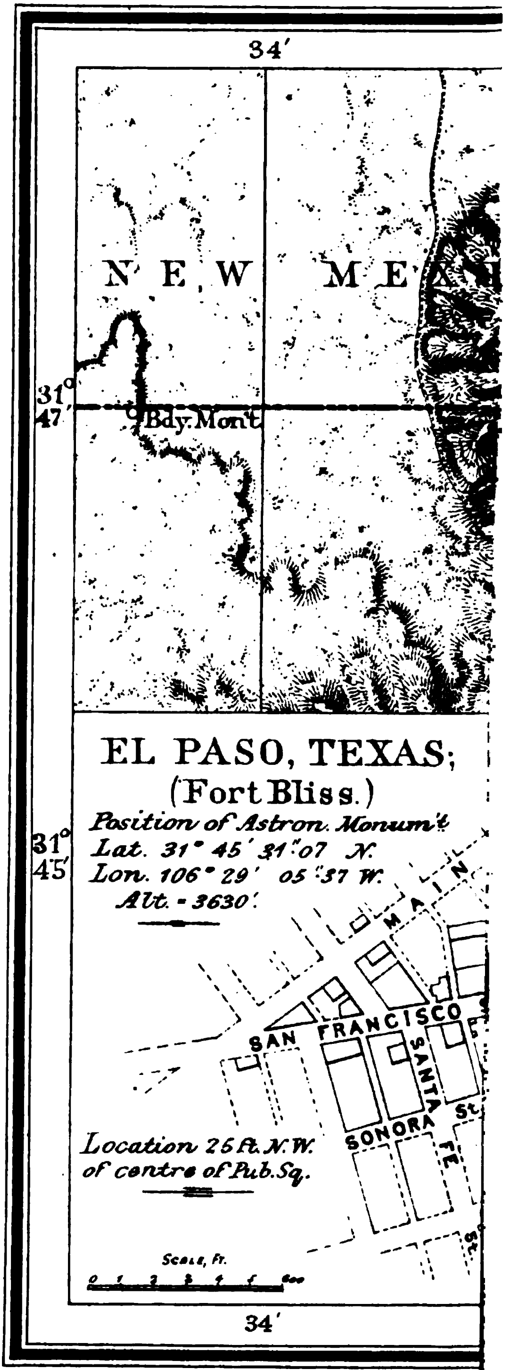
| Station. | Astronomical determination. | Correction due to flashes. | Final value. | In arc. |
|---|---|---|---|---|
|  | *h. m. s.* | *s.* | *h. m. s.* | ° ′ ″ |
| Frontera (observatory) ............... | 7 06 13. 02 | − 00. 65 | = 7 06 12. 37 | = 106 33 05. 55 |
| San Elceario (observatory)........... | 7 05 04. 43 | + 00. 64 | = 7 05 05. 07 | = 106 16 16. 05 |

Frontera is about 8 miles above and San Elceario 22 miles below El Paso.

The longitude of Sr. Salazar's observatory in El Paso, Mexico, was determined by Major Emory by 53 signal flashes during 4 nights to be $15^{s}.94$ east of Frontera. Hence its longitude is $7^{h}\ 5^{m}\ 56^{s}.43$, or 106° 29′ 6″.45. Its latitude was determined by Señor Salazar, the principal Mexican engineer, to be 31° 44′ 15″.7 north.

The bell-tower of the cathedral is 500 feet (5″.79) east and 200 feet (1″.98) north of Salazar's observatory (Mexican boundary report, page 141). Hence its longitude is 106° 29′ 0″.66, and latitude 31° 44′ 17″.68.

The longitude of the initial point of the boundary on the parallel of 31° 47′, in the Rio Grande, was derived from Frontera by a trigonometric survey by J. H. Clark, American assistant surveyor, given 106° 31′ 26″.50 (page 190, vol. 1 of report). The monument on the right bank of the river is 2″.7 west of the initial point as derived from the values of the longitudes of these two points given in table E, page 244, of Mexican boundary report. The resulting longitude is 106° 31′ 29″.20. Its latitude, 31° 47′ 0″, depends on that of the astronomical station on the left bank of the river, determined by J. H. Clark by 108 observations on 22 pairs of stars, with the zenith telescope, to be 31° 46′ 51″.29.



SKETCH of EL PASO, T

*Comparison of the two determinations.*

| Whose determination. | El Paso cathedral (bell-tower). | | | | | | Boundary monument on right bank of river. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Latitude. | | | Longitude. | | | Latitude. | | | Longitude. | | |
| | ° | ′ | ″ | ° | ′ | ″ | ° | ′ | ″ | ° | ′ | ″ |
| Mexican Boundary Commission | 31 | 44 | 17.68 | 106 | 29 | 0.66 | 31 | 47 | 0.00 | 106 | 31 | 29.20 |
| United States geographical survey west of 100th meridian | 31 | 44 | 14.85 | 106 | 28 | 59.24 | 31 | 46 | 58.28 | 106 | 31 | 33.49 |

**For relative position of points see sketch herewith.**

The accompanying plate shows the positions of the astronomical station of 1878, near Fort Bliss, Tex., of the initial astronomical station of the Mexican Boundary Commission, and also one of its derived positions at Frontera, as well as that of the boundary monument on the west bank of the Rio Grande.

### ASTRONOMICAL STATION AT FORT BAYARD, IN GRANT COUNTY, NEW MEXICO.

*Geographical position.*

Longitude, 108° 09′ 08″.77 west from Greenwich.

Latitude, 32° 47′ 40″.35 north.

Barometric altitude of the observatory above sea-level (top of monument, which is 3 feet high), 6,097 feet.

The monument is situated on the summit of a rounded hill of syenite rock just outside the quadrangle of the post at its western corner. It bears from the flag-staff in the parade-ground south 69° 24′ 0″, and is 636 feet distant from it, and the top of its foundation is 32 feet above the surface at the flag-staff and 6,094 feet above the level of the sea.

The monument is built of brick, 18 by 22 inches, on a solid rock foundation, a foot below the surface and 29 inches high above the surface (exclusive of the thickness of a capstone).

### PHYSICAL GEOGRAPHY DETAILS.

Fort Bayard lies at the axis of an anticlinal valley at the backbone of the continent, formed by the fracture of the arch of an elevated fold and denudation by weathering leaving the rims 20 miles apart, on the east the Santa Rita Mountains, and on the west the Burro and Pinos Altos Mountains. At Bayard syenitic rock forms the hills, and thence both eastward and westward newer and newer rocks come successively to the surface. Thus, towards the east, schists and gold-bearing slates (at Central City); quartzites and copper-bearing sandstones; limestone; quartzite and sandstone; gold-bearing slate; magnetite and hematite iron ores in massive beds; copper-bearing schists, crystalline limestone, and white marble at Santa Rita and Hanover copper mines; silver-bearing limestones (Georgetown); dikes, and superincumbent beds of volcanic rocks. Towards the west there is a similar succession of rocks up to the gold-bearing rocks at Pinos Altos and the silver-bearing limestones at Silver City.

The mountain-trough is diversified by a succession of rounded hills and rolling ridges and vales, none of which have flowing water, except the large vale in which Fort Bayard is situated, and a still larger one at the east, Hanover Valley. At some places the hilltops widen into tables, and at others there are narrow rocky ridges and ravines. Fort Bayard lies at the foot of low, round syenite hills, at the head of a vale that opens southward, and is drained by a rivulet that flows by Central City and in a few miles into Hanover Brook.

The hills and slopes are thinly covered by juniper, pine, and oak trees 20 to 40 feet high, scraggy and gnarled. There is good pasturage, especially in the long, winding vales where the water drains. The landscape is sweet and restful; with the quiet, green vales bright with wild flowers, and vistas of the mountains through the picturesquely shaped and grouped trees near and deep blue to the north, east, and west, and distant, faint blue, and vanishing to the south beyond the hazy plain; the Burro Mountains to the west; the Pinos Altos to the northwest; the Black range to the north; Santa Rita, forever kneeling and supplicating at the foot of an inaccessible precipice, to the east; the Floridas, grandly high and melting blue, to the southeast; and the Boca Grande and Hacheta Mountains, over the border in Mexico, far and faint and dreamy.

### METEOROLOGICAL CONDITIONS.

During the occupancy of the station, from September 23 to October 11, there were three cloudy days, on October 4, 5, and 6, when there was a little rain, and thunder-storms around the horizon on October 5. All the remaining days the sky was clear and bright, such weather as only a mountain climate affords.

High winds, from 10 to 20 or 25 miles an hour, prevailed, some time in every 24 hours, with intervals of calm and moderate winds. On September 29 and 30 and October 5 the velocity attained 40 to 50 miles an hour, and extra ropes and iron pins had to be used to secure the observatory tent, and by the morning of the 30th four of the ropes had parted. The blowing dust necessitated the taking apart and cleaning of the instrument on October 4. The winds interfered besides with the observations by often blowing the lights out.

Residents say that usually about October 10 a spell of cold, rainy weather sets in here. The bad weather on October 4 to 6 seemed to be a forerunner of it, and, if so, the astronomical observations were finished just in time.

The hourly meteorological observations were made from September 25 to October 11, and afford a very good barometric horary curve, of which the ordinates are as follows:

| Hour. | Correction to barom. reading. Inches. | Hour. | Correction to barom. reading. Inches. |
|---|---|---|---|
| 7 a. m | —0.018 | 7 p. m | +0.014 |
| 8 a. m | —0.030 | 8 p. m | +0.006 |
| 9 a. m | —0.037 | 9 p. m | —0.004 |
| 10 a. m | —0.036 | 10 p. m | —0.011 |
| 11 a. m | —0.026 | 11 p. m | —0.009 |
| 12 m | —0.007 | 12 p. m | —0.007 |
| 1 p. m | +0.010 | 1 a. m | —0.002 |
| 2 p. m | +0.027 | 2 a. m | —0.003 |
| 3 p. m | +0.033 | 3 a. m | +0.002 |
| 4 p. m | +0.041 | 4 a. m | +0.004 |
| 5 p. m | +0.034 | 5 a. m | —0.001 |
| 6 p. m | +0.023 | 6 a. m | —0.011 |

The maximum day temperatures ranged from 70° to 80° F., and the minimum night temperatures from 50° to 60°.

The prevailing winds were from the southwest, west, and northwest; less frequent from northeast, seldom from the east and southeast, and rarely from the north or south.

Day after day the sky was serene, with westerly winds, and only the winds from easterly quarters brought clouds and showers.

The lowest average humidity accompanied a southwest wind, being 0.25 to 0.35; with a northwest wind, 0.45; north, 0.50; northeast, 0.60; east, 0.60 to 0.80; southeast, 0.40; showing a regular increase of humidity and approach towards saturation as the wind veered from southwest by the north to east.

### PERSONNEL; OBSERVATORY; TELEGRAPH LINES.

The astronomical observer was Miles Rock, C. E., civilian assistant engineer, and Fred. W. Floyd, E. M., was the assistant and meteorological observer. Dr. August Herbst, an experienced observer, was employed temporarily to assist in the hourly barometric readings.

The observatory was a small wall-tent, with a seam ripped and fastened apart for a meridian opening.

On the first evening Fred. W. Mallory was the telegraph operator, and W. D. McChesney on the other four nights—both enlisted men in the United States Signal Corps. The telegraph wires used from Bayard to San Diego on the western and from Bayard to Santa Fé on the eastern circuit belong to the United States Military Telegraph, under Gen. A. J. Myer; the wires from San Diego, via Oakland, to Ogden, and from Santa Fé, via Pueblo and Cheyenne, to Ogden, belong to the Western Union Telegraph Company.

### DESCRIPTION OF INSTRUMENTS USED.

A portable transit by William Würdemann, Washington, marked No. 28, with micrometer-screw and zenith-telescope attachments for latitude observations by Talcott's method, was used. Its focal length is 3 feet; diameter of object-glass, 2¼ inches; diameter of pivots, 1¼ inches; the diagonal eye-piece magnifies 40 diameters. It has two finding circles, attached on opposite sides of the eye end of the tube, 3¼ inches in diameter, graduated to 20′ and reading to 1′ by vernier. Another circle, 6 inches in diameter, and graduated to 20′ and reading to 1′ by vernier, is attached with the latitude zenith-level to the object end of the tube.

The equatorial intervals of the threads from the mean of all 7 is as follows: For clamp east:

| | |
|---|---|
| 1–4 | 33.31 |
| 2–4 | 12.44 |
| 3–4 | 4.38 |
| 4–5 | 4.02 |
| 4–6 | 12.26 |
| 4–7 | 33.82 |

The value of a division of the striding level used in the observations here and at Fort Bliss is 1″.05, as determined by Professor Harkness's level-trier at the United States Naval Observatory. The value 62″.19 for one revolution of the micrometer-screw was employed in the reductions, but considered to include refraction. On discussing the results for latitude, a correction +0″.07 for every minute of the micrometer correction was added; this also includes refraction. So that the definitive value of one revolution is 62″.12 + 0.0724 — refraction, or about 62″.17. The value of one division of the zenith-telescope level is 1′.10.

The remaining instruments used were two chronometers: a mean-time chronometer, Hutton No. 288, which was used in exchanging signals, and compared with the sidereal immediately before and after the exchange of signals, and also at the beginning and end of the night's star observations. The local time was determined with a sidereal break-circuit chronometer, Negus No. 1344, and was connected with a single small Le Clanché cell and an ordinary telegraph-sounder to help the observer hear the seconds ticks.

All the observations were made by eye and ear.

The mean-time chronometer was carried to the telegraph office for exchange of signals, a distance of about 400 feet.

### POINTS WITH WHICH CONNECTIONS WERE MADE, &C.

Telegraphic connection was made with the engineer observatory at Ogden, Utah, on five nights: September 26 and 30, 1878, and October 1 and 3, by United States military telegraph through Silver City, N. Mex., 9 miles; Phœnix, Ariz., 360 miles; Fort Yuma, Cal., 200 miles, to San Diego, Cal., 175 miles; thence by lines of the Western Union Company through Los Angeles, 125 miles; San Francisco (Oakland), 450; to Ogden, 830, altogether about 2,150 miles. The signals were automatically repeated at Silver City, Phœnix, and San Diego.

On September 27 the connection was made by the United States military telegraph through Mesilla, 100 miles; Santa Fé, 300; Pueblo, 300; Denver, 125; Cheyenne, 110; to Ogden, 515, altogether about 1,450 miles. The signals were automatically repeated at Santa Fé, N. Mex.

On some nights, by the longer circuit, the impulses arrived so weak that the relay on the main line could not open the local circuit, and the signals had to be read by the faint click of the relay armature. This way is preferable whenever it is quiet enough to hear, as the click is sharp and it reduces the automatic repetitions by one.

The observations were computed and arranged, as they follow, by Professor T. H. Safford.

*Tabulation of stars used for determination of time at Ogden, Utah, and Fort Bayard, N. Mex.*

| Name of star. | Ogden, Utah. | | | | | Fort Bayard, N. Mex. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | September 26. | September 27. | September 30. | October 1. | October 3. | September 26. | September 27. | September 30. | October 1. | October 3. |
| 50 Draconis | × | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| γ Lyræ | × | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| ζ Aquilæ | × | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| ι Lyræ | × | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 19 Lyræ | × | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| δ Draconis | × | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 9 Cygni | ...... | ...... | ...... | × | | ...... | ...... | ...... | ...... | ...... |
| φ Cygni | | × | ...... | × | | ...... | ...... | ...... | ...... | ...... |
| 28 Heis Cygni | | | × | × | | ...... | ...... | ...... | ...... | ...... |
| δ Sagittæ | | | × | × | × | ...... | ...... | ...... | ...... | ...... |
| 12 Vulpeculæ | | | × | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| ι Draconis | | | ...... | × | × | ...... | ...... | ...... | ...... | ...... |
| γ Sagittæ | | | ...... | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| 15 Vulpeculæ | ...... | ...... | × | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| η Sagittæ | ...... | ...... | × | ...... | ...... | ...... | ...... | ...... | ...... | ...... |
| ρ Aquilæ | ...... | ...... | ...... | × | × | ...... | ...... | ...... | ...... | ...... |
| κ Cephei | ...... | × | × | × | × | ...... | ...... | ...... | ...... | ...... |

*Tabulation of stars used for determination of time at Ogden, Utah, &c.*—Continued.

| Name of star. | Ogden, Utah. | | | | | Fort Bayard, N. Mex. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | September 26. | September 27. | September 30. | October 1. | October 3. | September 26. | September 27. | September 30. | October 1. | October 3. |
| γ Cygni | | × | | | | | | | | |
| 39 Cygni | | | | × | × | | | | | |
| 40 Cygni | | × | | | | | | | | |
| 41 Cygni | | | | × | × | | | | | |
| ε Delphini | | × | × | × | × | | | | | |
| Groombr. 3241 | | | | | | × | | | | |
| 73 Draconis | | × | × | × | × | | | | | |
| α Delphini | | | | | | × | | | | |
| α Cygni | | | | | | × | | | | |
| Pi. xx, 283 | | × | | | | | | | | |
| ε Cygni | | | × | | | × | | | | |
| μ Aquarii | | | | | | × | | | | |
| Pi. xx, 358 | | | × | | | | | | | |
| 32 Vulpeculæ | | | × | | | | | | | |
| Br. 2749 | | | × | | | × | | | | |
| 61 Cygni | | | | | | × | | | | |
| ζ Cygni | | | | | | × | | | | |
| τ Cygni | | | | | | × | × | × | × | × |
| α Cephei | | | | | | × | | | | |
| 1 Pegasi | | | | | | | × | × | × | × |
| 1 H. Draconis s. p | | | | | | × | × | × | × | × |
| β Cephei | | | | | | | × | × | × | × |
| 74 Cygni | | | | | | | × | × | × | × |
| ε Pagasi | | | | | | | × | × | × | × |
| π² Cygni | | | | | | | × | × | × | × |
| 16 Pegasi | | | | | | | × | × | × | × |
| 79 Draconis | | | | | | | × | × | × | × |
| α Aquarii | | | | | | | × | × | × | × |
| 27 Pegasi | | | | | | | | × | | × |
| π Pegasi | | | | | | | | | × | × |
| 226 Cephei B | | × | | | | | | | | |
| η Pegasi | × | | | | | | | | | |
| λ Pegasi | × | | | | | | | | | |
| μ Pegasi | | × | | | | | | | | |
| ι Cephei | × | | | | × | | | | | |
| B. A. C. 7984 | | × | | | | | | | | |
| Pi. xxii, 261 | | × | | | | | | | | |
| β Pegasi | × | × | | | × | | | | | |
| 56 Pegasi | × | × | | | × | | | | | |
| π Cephei | × | × | | | | | | | | |
| Pi. xxiii | | | | | × | | | | | |
| o Cephei | | | | | × | × | × | | | |
| τ Pegasi | | × | | × | | × | × | | | |
| υ Pegasi | | × | | × | | | | | | |
| 70 Pegasi | | × | | | | | | | | |
| λ Draconis s. p | | | | | | × | × | | | × |
| 72 Pegasi | | × | × | × | × | | | | | |
| 153 Heis Pegasi | | | | × | | | | | | |
| λ Andromedæ | | | | | | × | × | | | × |
| ι Piscium | | | | | | × | × | | | × |
| γ Cephei | | | × | × | × | | | | | × |
| 78 Pegasi | | | | | × | | | | | |
| 41 H. Cephei | | | | × | | | | | | |
| 79 Pegasi | | | | | × | | | | | |
| φ Pegasi | | | | | × | | | | | |
| Groombr. 4163 | | | | | | × | × | | | × |
| ψ Pegasi | | | | × | | | | | | |
| ω Piscium | | | | | | | × | | × | × |
| 85 Pegasi | | | | × | | | | | | |
| α Andromedæ | | | × | × | | × | × | × | × | × |
| 22 Andromedæ | | | | | | | | | × | × |
| 4 H. Draconis, s. p | | | | | | | | × | | |
| γ Pegasi | | | × | × | | × | × | | × | × |
| ι Ceti | | | | | | | | × | | |
| 6 B. Ursæ Minoris s. p | | | | | | × | × | | × | × |
| 12 Ceti | | | | | | × | | × | × | × |
| π Andromedræ | | | | | | × | | × | × | × |
| 21 Cassiopeiæ | | | | | | | | × | × | |
| δ Piscium | | | | | | | | × | × | |
| 32 H. Camelopard. s. p | | | | | | | | | × | |
| μ Andromedæ | | | | | | | | × | | |
| ε Piscium | | | | | | | | × | | |
| β Andromedæ | | | | | | | | × | | |
| Polaris | | | | | | | | × | | |

*Fort Bayard, September 26, 1878; before signals.*

| Name of star. | Clamp. | T. | | | B*b*. | A*a*. | C*c*. | T′. | | | A. R. | | | Δ T. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| Gr. 3241 | W. | 20 | 38 | 55.37 | − 0.09 | − 4.13 | − 0.72 | 20 | 38 | 50.43 | 20 | 30 | 82.65 | − 8 | 17.78 |
| α Delphini | W. | | 43 | 19.11 | − 0.04 | + 0.62 | − 0.23 | | 43 | 19.46 | 20 | 34 | 01.69 | 8 | 17.77 |
| α Cygni | W. | | 45 | 38.26 | − 0.05 | − 0.59 | − 0.31 | | 45 | 37.31 | 20 | 37 | 19.18 | 8 | 18.13 |
| τ Cygni | W. | | 49 | 38.33 | − 0.04 | − 0.03 | − 0.27 | | 49 | 37.99 | 20 | 41 | 19.62 | 8 | 18.37 |
| μ Aquarii | W. | 20 | 54 | 25.53 | − 0.03 | + 1.36 | − 0.23 | 20 | 54 | 26.63 | 20 | 46 | 08.40 | 8 | 18.23 |
| Brdl. 2749 | W. | 21 | 01 | 33.94 | − 0.14 | − 8.54 | − 1.29 | 21 | 01 | 23.97 | 20 | 58 | 04.53 | 8 | 19.44 |
| 61 Cygni | E. | | 09 | 47.53 | − 0.04 | − 0.24 | + 0.28 | | 09 | 47.53 | 21 | 01 | 29.08 | 8 | 18.45 |
| ζ Cygni | E. | | 16 | 06.08 | − 0.04 | + 0.12 | + 0.26 | | 16 | 06.42 | 21 | 07 | 47.98 | 8 | 18.44 |
| τ Cygni | E. | | 18 | 16.80 | − 0.04 | − 0.21 | + 0.28 | | 18 | 16.83 | 21 | 09 | 58.51 | 8 | 18.32 |
| α Cephei | E. | | 24 | 02.75 | − 0.06 | − 2.09 | + 0.47 | | 24 | 01.07 | 21 | 15 | 42.69 | 8 | 18.38 |
| 1 H. Draconis | E. | 21 | 27 | 46.25 | + 0.10 | + 12.81 | − 1.57 | 21 | 27 | 57.59 | 21 | 19 | 38.08 | − 8 | 19.51 |

NORMAL EQUATIONS.

$a_0 = +1^s.8 \qquad c_0 = +0^s.25 \qquad \Delta T_0 = -8^m\ 18^s.25 \text{ for } 21^h.0$

$$
\begin{aligned}
&\overset{s.}{\phantom{0}}\\
0 &= +0.389 + 7.13\, d\Delta T - 0.40\, da - 1.40\, dc.\\
0 &= -1.469 - 0.40\, d\Delta T + 7.14\, da - 1.22\, dc.\\
0 &= +0.757 - -1.40\, d\Delta T - 1.22\, da + 20.87\, dc.
\end{aligned}
$$

$$
\begin{aligned}
& & &\phantom{=-}\overset{m.}{\phantom{8}}\ \ \overset{s.}{\phantom{1}}\\
d\Delta T &= -0.048 & \Delta T &= -8\ 18.298\ (\text{wt.} = 7.02)\\
da &= +0.198 & a &= +\ \ \ 1.998\ (\text{wt.} = 7.04\\
dc &= -0.028 & c &= +\ \ \ 0.222\ (\text{wt.} = 20.36)
\end{aligned}
$$

*Fort Bayard, September 26, 1878; after signals.*

| Name of star. | Clamp. | T. | B*b*. | A*a*. | C*c*. | T′. | A. R. | ΔT. |
|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *h. m. s.* | *m. s.* |
| o Cephei | E. | 23 22 02.95 | − 0.14 | − 2.55 | + 0.49 | 23 22 00.75 | 23 13 41.74 | − 8 19.01 |
| τ Pegasi | E. | 22 58.34 | − 0.07 | + 0.32 | + 0.20 | 22 58.79 | 23 14 40.05 | 8 18.74 |
| λ Draconis S. P | E. | 32 24.06 | + 0.04 | + 4.91 | − 0.54 | 32 28.47 | 23 24 09.86 | 8 18.61 |
| λ Andromedæ | E. | 39 58.97 | − 0.09 | − 0.56 | + 0.27 | 39 58.59 | 23 31 40.05 | 8 18.54 |
| ι Piscium | E. | 42 02.28 | − 0.06 | + 0.81 | + 0.19 | 42 3 22 | 23 33 44.77 | 8 18.45 |
| Groombr. 4163 | W. | 23 57 24.14 | + 0.05 | − 4.03 | − 0.66 | 23 57 19.50 | 23 49 00.51 | 8 18.99 |
| α Andromedæ | W. | 0 10 27.93 | + 0.02 | + 0.15 | − 0.21 | 0 10 27.89 | 0 02 99.26 | 8 18.63 |
| γ Pegasi | W. | 15 19.70 | + 0.02 | + 0.56 | − 0.19 | 15 20.09 | 0 07 01.51 | 8 18.58 |
| 6 B. Ursæ Minoris S. P | W. | 21 18.04 | − 0.33 | +51.81 | + 6.54 | 22 16.06 | 0 13 50.71 | 8 25.35 |
| 12 Ceti | W. | 32 11.08 | + 0.01 | + 1.05 | − 0.19 | 32 11.95 | 0 23 53.07 | 8 18.88 |
| π Andromedæ | W. | 0 38 45.55 | + 0.02 | − 0.01 | − 0.22 | 0 38 45.34 | 0 30 26.44 | − 8 18.90 |

NORMAL EQUATIONS.

$a_0 = +1^s.8 \qquad c_0 = +0^s.25 \qquad \Delta T_0 = -8^m.\ 18^s.70$ for $0^h.0$.

$$\begin{aligned} &\quad\ s. \\ 0 &= -0.009 + 6.96\, d\Delta T + 1.27\, da - 2.09\, dc. \\ 0 &= +0.559 + 1.27\, d\Delta T + 7.43\, da - 0.44\, dc. \\ 0 &= +1.132 - 2.09\, d\Delta T - 0.44\, da + 18.42\, dc. \end{aligned}$$

$$\begin{aligned} & \quad\ s. & & \quad\ m.\ \ s. \\ d\Delta T &= -0.004 & \Delta T &= -8\ 18.704\ (\text{wt.} = 6.52.) \\ da &= -0.078 & a &= +\ \ 1.722\ (\text{wt.} = 7.20.) \\ d &= -0.064 & c &= +\ \ 0.186\ (\text{wt.} = 17.79.) \end{aligned}$$

*Fort Bayard, September 27, 1878; before signals.*

| Name of stars. | Clamp. | T. | | | B*b*. | A*a*. | C*c*. | T′. | | | A. R. | | | Δ T. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| τ Cygni | W. | 21 | 18 | 19.45 | − 0.11 | + 0.01 | − 0.37 | 21 | 18 | 18.98 | 21 | 09 | 58.50 | − 8 | 20.48 |
| 1 Pegasi | W. | | 24 | 51.00 | − 0.09 | − 0.02 | − 0.31 | | 24 | 50.58 | 21 | 16 | 30.20 | 8 | 20.38 |
| 1 H. Draconis S. P | W. | | 27 | 57.02 | + 0.27 | − 0.56 | + 2.05 | | 27 | 58.78 | 21 | 19 | 38.21 | 8 | 20.57 |
| β Cephei | W. | | 35 | 28.49 | − 0.21 | + 0.15 | − 0.85 | | 35 | 27.58 | 21 | 27 | 07.36 | 8 | 20.22 |
| 74 Cygni | W. | | 40 | 27.70 | − 0.12 | + 0.01 | − 0.38 | | 40 | 27.21 | 21 | 32 | 06.90 | 8 | 20.31 |
| ε Pegasi | E. | | 46 | 35.45 | − 0.13 | − 0.04 | + 0.29 | | 46 | 35.57 | 21 | 38 | 15.48 | 8 | 20.09 |
| π² Cygni | E. | | 50 | 40.59 | − 0.21 | + 0.04 | + 0.44 | | 50 | 40.86 | 21 | 42 | 20.49 | 8 | 20.37 |
| 16 Pegasi | E. | | 55 | 54.54 | − 0.15 | − 0.01 | + 0.32 | | 55 | 54.70 | 21 | 47 | 34.33 | 8 | 20.37 |
| 79 Draconis | E. | 21 | 59 | 43.43 | − 0.37 | + 0.19 | + 1.00 | 21 | 59 | 44.25 | 21 | 51 | 23.75 | 8 | 20.50 |
| α Aquarii | E. | 22 | 07 | 55.31 | − 0.12 | − 0.05 | + 0.29 | 22 | 07 | 55.43 | 21 | 59 | 35.12 | 8 | 20.31 |

NORMAL EQUATIONS.

$a_0 = -0^s.20 \qquad c_0 = +0^s.25 \qquad \Delta T_0 = -8^m.\ 20^s.35 \text{ for } 21^h.7$

$$
\begin{aligned}
& \phantom{-}\,s. \\
0 &= -0.202 + 7.06\, d\Delta T + 0.21\, da + 1.38\, dc. \\
0 &= -0.888 + 0.21\, d\Delta T + 6.23\, da + 4.31\, dc. \\
0 &= -1.258 + 1.38\, d\Delta T + 4.31\, da + 18.48\, dc.
\end{aligned}
$$

$$
\begin{array}{rlrl}
 & s. & & m.\quad s. \\
d\Delta T = & +0.017 & \Delta T = & -8\ 20.333\ (\text{wt.} = 6.96.) \\
da = & +0.113 & a = & -\quad 0.087\ (\text{wt.} = 5.22.) \\
dc = & +0.040 & c = & +\quad 0.290\ (\text{wt.} = 15.29.)
\end{array}
$$

*Fort Bayard, September 27, 1878; after signals.*

| Name of star. | Clamp. | T. | | | B b. | A a. | C c. | T'. | | | A. R. | | | Δ T. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| ο Cephei | E. | 23 | 22 | 2.02 | − 0.27 | + 0.48 | + 0.71 | 23 | 22 | 2.94 | 23 | 13 | 41.73 | − 8 | 21.21 |
| τ Pegasi | E. | | 23 | 0.46 | − 0.13 | − 0.06 | + 0.30 | | 23 | 0.57 | 23 | 14 | 40.05 | 8 | 20.52 |
| λ Draconis, S. P | E. | | 32 | 32.33 | + 0.08 | − 0.92 | − 0.80 | | 32 | 30.69 | 23 | 24 | 09.88 | 8 | 20.81 |
| λ Andromedæ | E. | | 40 | 0.20 | − 0.17 | + 0.13 | + 0.39 | | 40 | 00.55 | 23 | 31 | 40.05 | 8 | 20.50 |
| ι Piscium | E. | | 42 | 5.34 | − 0.11 | − 0.15 | + 0.28 | | 42 | 05.36 | 23 | 33 | 44.78 | 8 | 20.58 |
| Grombr. 4163 | W. | 23 | 57 | 21.97 | − 0.32 | + 0.75 | − 0.98 | 23 | 57 | 21.42 | 23 | 49 | 00.50 | 8 | 20.92 |
| ω Piscium | W. | 0 | 1 | 28.11 | − 0.11 | − 0.14 | − 0.28 | 0 | 01 | 27.58 | 23 | 53 | 07.06 | 8 | 20.52 |
| α Andromedæ | W. | | 10 | 30.17 | − 0.13 | − 0.03 | − 0.31 | | 10 | 29.70 | 0 | 02 | 09.26 | 8 | 20.44 |
| γ Pegasi | W. | | 15 | 22.47 | − 0.12 | − 0.10 | − 0.28 | | 15 | 21.97 | 0 | 07 | 01.52 | 8 | 20.45 |
| 6 B. Ursæ Minoris, S. P | W. | | 22 | 11.09 | + 2.16 | − 9.69 | + 9.64 | | 22 | 13.20 | 0 | 13 | 50.70 | 8 | 22.50 |
| 6 B. Ursæ Minoris, S. P | E. | 0 | 22 | 33.12 | + 2.83 | − 9.69 | − 9.64 | 0 | 22 | 16.62 | 0 | 13 | 50.70 | − 8 | 25.92 |

NORMAL EQUATIONS.

$$a_0 = -0^s.2 \qquad c_0 = +0^s.25 \qquad \Delta T_0 = -8^m\,20^s.50 \text{ for } 0^h.0$$

$$\begin{aligned} &\quad s. \\ 0 &= +0.706 + 6.87\; d\Delta T + 1.14\; da - 1.21\; dc \\ 0 &= +1.372 + 1.14\; d\Delta T + 9.99\; da - 2.89\; dc \\ 0 &= -0.971 - 1.21\; d\Delta T - 2.89\; da + 22.15\; dc \end{aligned}$$

$$\begin{aligned} & \qquad\quad s. \qquad\qquad\qquad\quad m. \quad s. \\ d\Delta T &= -0.079 \quad \Delta T = -8 \quad 20.579 \text{ (wt.} = 6.70) \\ da &= -0.122 \quad a = - \quad 0.322 \text{ (wt.} = 9.47) \\ dc &= +0.024 \quad c = + \quad 0.274 \text{ (wt.} = 21.20) \end{aligned}$$

*Fort Bayard, September 30, 1878; before signals.*

| Name of star. | Clamp. | T. |  |  | *b* B. | *a* A. | *c* C. | T'. |  |  | A. R. |  |  | Δ T. |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| τ Cygni | E. | 21 | 18 | 22.39 | − 0.05 | − 0.02 | + 0.19 | 21 | 18 | 22.51 | 21 | 09 | 58.45 | − 8 | 24.06 |
| 1 Pegasi | E. |  | 24 | 54.08 | − 0.05 | + 0.03 | + 0.17 |  | 24 | 54.23 | 21 | 16 | 30.17 | 8 | 24.06 |
| 1 H. Draconis, s. p. | E. |  | 28 | 03.04 | + 0.13 | + 1.14 | − 1.09 |  | 28 | 03.22 | 21 | 19 | 38.61 | 8 | 24.61 |
| β Cephei | E. |  | 35 | 31.47 | − 0.10 | − 0.32 | + 0.45 |  | 35 | 31.50 | 21 | 27 | 07.23 | 8 | 24.27 |
| 74 Cygni | E, |  | 40 | 30.83 | + 0.06 | − 0.03 | + 0.20 |  | 40 | 31.06 | 21 | 32 | 06.86 | 8 | 24.20 |
| ε Pegasi | W. |  | 46 | 39.52 | + 0.03 | + 0.07 | − 0.16 |  | 46 | 39.46 | 21 | 38 | 15.45 | 8 | 24.01 |
| π² Cygni | W. |  | 50 | 44.90 | + 0.04 | − 0.07 | − 0.23 |  | 50 | 44.64 | 21 | 42 | 20.44 | 8 | 24.20 |
| 16 Pegasi | W. |  | 55 | 58.47 | + 0.03 | + 0.03 | − 0.17 |  | 55 | 58.36 | 21 | 47 | 34.30 | 8 | 24.06 |
| 79 Draconis | W. | 21 | 59 | 48.59 | + 0.07 | − 0.40 | − 0.53 | 21 | 59 | 47.73 | 21 | 51 | 23.62 | 8 | 24.11 |
| α Aquarii | W. | 22 | 07 | 59.12 | + 0.02 | + 0.10 | − 0.15 | 22 | 07 | 59.09 | 21 | 59 | 35.10 | 8 | 23.99 |
| 27 Pegasi | W. | 22 | 12 | 17.30 | + 0.03 | 0.00 | − 0.18 | 22 | 12 | 17.15 | 22 | 03 | 52.95 | − 8 | 24.20 |

NORMAL EQUATIONS.

$a_0 = 0 \quad c_0 = +0^s.25 . \quad \Delta T_0 = -8^m\, 24.^s10$ for $21^h.8$

$$
\begin{aligned}
&\quad\ \ s.\\
0 &= -0.198 + 8.05\, d\Delta T + 0.02\, da - 2.54\, dc\\
0 &= -1.567 + 0.02\, d\Delta T + 6.63\, da - 4.06\, dc\\
0 &= +2.690 - 2.54\, d\Delta T - 4.06\, da + 20.75\, dc
\end{aligned}
$$

$$
\begin{aligned}
&\quad\ \ s. & &\quad\ \ m.\ \ s.\\
d\Delta T &= -0.006 & \Delta T &= -8\ 24.106\ (\text{wt.} = 7.70)\\
da &= +0.178 & a &= +\ \ 0.178\ (\text{wt.} = 5.81)\\
dc &= -0.096 & c &= +\ \ 0.154\ (\text{wt.} = 17.47)
\end{aligned}
$$

*Fort Bayard, September 30, 1878; after signals.*

| Name of star. | Clamp. | T. | B*b*. | A*a*. | C*c*. | T'. | A. R. | Δ T. |
|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *h. m. s.* | *m. s.* |
| α Andromedæ | W. | 0 10 33.47 | + 0.03 | 0.00 | − 0.13 | 0 10 33.37 | 0 02 09.28 | − 8 24.09 |
| 4 H. Draconis, s. p. | W. | 14 50.51 | − 0.04 | + 0.17 | + 0.57 | 14 51.21 | 0 06 26.62 | 8 24.59 |
| ι Ceti | W. | 21 41.60 | + 0.02 | + 0.03 | − 0.12 | 21 41.53 | 0 13 17.08 | 8 24.45 |
| 12 Ceti | W. | 32 17.55 | + 0.02 | + 0.02 | − 0.12 | 32 17.47 | 0 23 53.10 | 8 24.37 |
| π Andromedæ | W. | 38 51.08 | + 0.03 | 0.00 | − 0.14 | 38 50.97 | 0 30 26.47 | 8 24.50 |
| 21 Cassiopeiæ | W. | 46 09.44 | + 0.06 | − 0.09 | − 0.43 | 46 8.98 | 0 37 44,25 | 8 24.73 |
| δ Piscium | E. | 50 49.81 | + 0.02 | + 0.02 | + 0.12 | 50 49.97 | 0 42 25.52 | 8 24.45 |
| μ Andromedæ | E. | 0 58 28.02 | + 0.03 | 0.00 | + 0.15 | 0 58 28.20 | 0 50 03.76 | 8 24.44 |
| ε Piscium | E. | 1 05 05.32 | + 0.02 | + 0.02 | + 0.12 | 1 05 5.48 | 0 56 41.05 | 8 24.43 |
| β Andromedæ | E. | 11 23.07 | + 0.03 | 0.00 | + 0.14 | 11 23.24 | 1 02 58.87 | 8 24.37 |
| Polaris | E. | 1 23 19.56 | + 0.50 | − 1.35 | + 4.95 | 1 23 23.66 | 1 14 59.94 | − 8 23.72 |

NORMAL EQUATIONS.

$a_0=0 \qquad c_0=+0^s.25 \qquad \Delta T_0=-8^m.24^s.40$ for $0^h.7$

$$
\begin{aligned}
&\overset{s.}{0=-0.015}+7.93\ d\Delta T+2.11\ da+\ 0.08\ dc\\
&0=-0.112+2.11\ d\Delta T+9.04\ da+\ 1.63\ dc\\
&0=+2.734+0.08\ d\Delta T+1.63\ da+20.82\ dc
\end{aligned}
$$

$$
\begin{aligned}
d\Delta T&=\overset{s.}{-0.007} & \Delta T&=\overset{m.}{-8}\ \overset{s.}{24.407}\ (\text{wt.}=\ 7.44)\\
da&=+0.038 & a&=+\ \ 0.038\ (\text{wt.}=\ 8.35)\\
dc&=-0.134 & c&=+\ \ 0.116\ (\text{wt.}=20.51)
\end{aligned}
$$

*Fort Bayard, October 1, 1878; before signals.*

| Name of star. | Clamp. | T. | Bb. | Δa. | Cc. | T′. | A. R. | ΔT. |
|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *h. m. s.* | *m. s.* |
| τ Cygni | E. | 21 18 24.67 | − 0.25 | 0.00 | + 0.34 | 21 18 24.76 | 21 09 58.43 | − 8 26.33 |
| 7 Pegasi | E. | 24 55.89 | − 0 20 | 0.00 | + 0.29 | 24 55.98 | 21 16 30.15 | 8 25.83 |
| 1 H. Draconis, s. p | E. | 28 06.82 | + 0.59 | − 0.09 | − 1.93 | 28 05.89 | 21 19 38.75 | 8 26.64 |
| β Cephei | E. | 35 32.71 | − 0.46 | + 0.08 | + 0.80 | 35 33.08 | 21 27 07.18 | 8 25.90 |
| 74 Cygni | E. | 40 32.73 | − 0.25 | 0.00 | + 0.36 | 40 32.84 | 21 32 06.83 | 8 26.01 |
| ε Pegasi | W. | 46 41.58 | − 0.15 | − 0.01 | − 0.28 | 46 41.14 | 21 38 15.44 | 8 25.70 |
| π² Cygni | W. | 50 47.20 | − 0.24 | + 0.01 | − 0.41 | 50 46.56 | 21 42 20.42 | 8 26.14 |
| 16 Pegasi | W. | 56 00.57 | − 0.18 | 0.00 | − 0.30 | 56 00.09 | 21 47 34.29 | 8 25.80 |
| 79 Draconis | W. | 21 59 50.97 | − 0.43 | + 0.08 | − 0.94 | 21 59 49.63 | 21 51 23.57 | 8 26.06 |
| α Aquarii | W. | 22 08 01.38 | − 0.14 | − 0.01 | − 0.27 | 22 08 00.96 | 21 59 35.09 | 8 25.87 |
| π Pegasi | W. | 22 13 04.37 | − 0.19 | 0.00 | − 0.32 | 22 13 03.86 | 22 04 37.80 | − 8 26.06 |

NORMAL EQUATIONS.

$a_0 = -0^s.20 \qquad c_0 = +0^s.25 \qquad \Delta T_0 = -8^m\ 26^s.00$ for $21^h.8$

$$\begin{aligned} &\phantom{0=}\ ^{s.} \\ 0 &= -0.232 + 7.95\, d\Delta T - 0.03\, da - 2.44\, dc \\ 0 &= -1.095 - 0.03\, d\Delta T + 6.60\, da - 4.00\, dc \\ 0 &= +0.342 - 2.44\, d\Delta T - 4.00\, da + 20.65\, dc \end{aligned}$$

$$\begin{aligned} d\Delta T &= +0.037^s & \Delta T &= -\ 8^m\ 25^s.963\ (\text{wt.} = 7.62) \\ da &= +0.180 & a &= -\ 0.020\ (\text{wt.} = 5.80) \\ dc &= +0.023 & c &= +\ 0.273\ (\text{wt.} = 17.47) \end{aligned}$$

*Fort Bayard, October 1, 1878; after signals.*

| Name of star. | Clamp. | T. | B *b*. | A *a*. | C *c*. | T′. | A. R. | ΔT. |
|---|---|---|---|---|---|---|---|---|
| | | *h.* *m.* *s.* | *s.* | *s.* | *s.* | *h.* *m.* *s.* | *h.* *m.* *s.* | *m.* *s.* |
| ω Piscium | W. | 0 01 33.43 | − 0.11 | − 0.10 | − 0.32 | 0 01 32.90 | 23 53 07.07 | − 8 25.83 |
| α Andromedæ | W. | 10 35.90 | − 0.14 | − 0.02 | − 0.36 | 10 35.38 | 0 02 09.28 | 8 26.10 |
| 22 Andromedæ | W. | 12 30.20 | − 0.17 | + 0.07 | − 0.45 | 12 29.65 | 0 04 03.50 | 8 26.15 |
| γ Pegasi | W. | 15 27.96 | − 0.12 | − 0.07 | − 0.33 | 15 27.44 | 0 07 01.53 | 8 25.91 |
| 6 B. Ursæ Minoris, s. p | W. | 22 09.81 | + 2.26 | − 6.35 | + 11.11 | 22 16.83 | 0 13 50.66 | 8 26.17 |
| 12 Ceti | E. | 32 19.04 | − 0.11 | − 0.13 | + 0.32 | 32 19.12 | 0 23 53.11 | 8 26.01 |
| π Andromedæ | E. | 38 52.25 | − 0.16 | 0.00 | + 0.38 | 38 52.47 | 0 30 26.48 | 8 25.99 |
| 21 Cassiopeiæ | E. | 46 08.94 | − 0.37 | + 0.52 | + 1.17 | 46 10.26 | 0 37 44.26 | 8 26.00 |
| δ Piscium | E. | 50 51.52 | − 0.12 | − 0.09 | + 0.32 | 50 51.63 | 0 42 25.53 | 8 26.10 |
| 32 H. Camelop., s. p | E. | 0 56 37.98 | + 0.59 | − 1.82 | − 3.06 | 0 56 33.69 | 0 48 07.45 | − 8 26.24 |

NORMAL EQUATIONS,

$a_0 = -0^s.20 \qquad c_0 = +0^s.25 \qquad \Delta T_0 = -8^m\ 26^s.00$ for $0^h.5$

$$0 = +0^s.120 + 6.94\, d\Delta T + 1.47\, da - 0.50\, dc$$
$$0 = +0.248 + 1.47\, d\Delta T + 8.01\, da - 2.18\, dc$$
$$0 = -1.285 - 0.50\, d\Delta T - 2.18\, da + 18.94\, dc$$

$d\Delta T = -0^s.010 \qquad \Delta T = -8^m\ 26^s.010$ (wt. = 6.67)
$da = -0.011 \qquad a = -\ 0.211$ (wt. = 7.46)
$dc = +0.066 \qquad c = +\ 0.316$ (wt. = 18.34)

*Fort Bayard, October 3, 1878; before signals.*

| Name of star. | Clamp. | T. | B*b*. | A*a*. | C*c*. | T′. | A. R. | ΔT. |
|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *h. m. s.* | *m. s.* |
| τ Cygni | E. | 21 18 27.13 | − 0.06 | + 0.03 | + 0.42 | 21 18 27.52 | 21 09 58.39 | − 8 29.13 |
| 1 Pegasi | E. | 21 24 58.85 | − 0.05 | − 0.06 | + 0.35 | 24 59.09 | 21 16 30.13 | 8 28.96 |
| 1 H. Draconis, s. p | E. | 21 28 11.94 | + 0.14 | − 1.61 | − 2.34 | 28 08.13 | 21 19 39.02 | 8 29.11 |
| β Cephei | E. | 21 35 35.01 | − 0.11 | + 0.44 | + 0.97 | 35 36.31 | 21 27 07.09 | 8 29.22 |
| 7 Cygni | E. | 21 40 35.65 | − 0.06 | + 0.04 | + 0.43 | 40 36.06 | 21 32 06.81 | 8 29.25 |
| θ Pegasi | W. | 21 46 45.04 | + 0.01 | − 0.10 | − 0.34 | 46 44.61 | 21 38 15.42 | 8 29.19 |
| π² Cygni | W. | 21 50 50.15 | + 0.01 | + 0.10 | − 0.50 | 50 49.76 | 21 42 20.39 | 8 29.37 |
| 16 Pegasi | W. | 21 56 03.71 | + 0.01 | − 0.04 | − 0.37 | 56 03.31 | 21 47 34.27 | 8 29.04 |
| 79 Draconis | W. | 21 59 52.81 | + 0.02 | + 0.56 | − 1.14 | 21 59 52.25 | 21 51 23.47 | 8 28.78 |
| α Aquarii | W. | 22 08 04.62 | + 0.01 | − 0.14 | − 0.33 | 22 08 04.16 | 21 59 35.08 | 8 29.08 |
| 27 Pegasi | W. | 22 12 22.63 | + 0.01 | 0.00 | − 0.39 | 12 22.25 | 22 03 52.92 | 8 29.33 |
| π Pegasi | W. | 22 13 07.37 | + 0.01 | 0.00 | − 0.39 | 22 13 06.99 | 22 04 37.78 | − 8 29.21 |

NORMAL EQUATIONS.

$a_0 = -0^s.20$ $c_0 = +0^s.25$ $\Delta T_0 = -8^m\ 29^s.10$ for $21^h.8$

$$\begin{aligned}
&\quad\ \ \ s.\\
0 &= +0.804 + 8.98\ d\Delta T - 0.19\ da - 3.58\ dc\\
0 &= +0.670 - 0.19\ d\Delta T + 6.73\ da - 4.16\ dc\\
0 &= -2.254 - 3.58\ d\Delta T - 4.16\ da + 27.43\ dc
\end{aligned}$$

$$\begin{array}{llll}
 & s. & & m.\ \ s.\\
d\Delta T = & -0.058 & \Delta T = & -8\ \ 29.158\ (\text{wt.} = 8.30)\\
da = & -0.051 & a = & -\ \ 0.251\ (\text{wt.} = 5.87)\\
dc = & +0.082 & c = & +\ \ 0.332\ (\text{wt.} = 18.37)
\end{array}$$

*Fort Bayard, October 3, 1878; after signals.*

| Name of star. | Clamp. | T. | | | B*b*. | A*a*. | C*c*. | T′. | | | A. R. | | | ΔT. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| λ Draconis, s. p | W. | 23 | 32 | 38.65 | −0.02 | −0.49 | + 1.15 | 23 | 32 | 39.29 | 23 | 24 | 10.03 | − 8 | 29.26 |
| λ Andromedæ | W. | | 40 | 09,72 | +0.04 | +0.06 | − 0.57 | | 40 | 09,25 | 23 | 31 | 40.04 | 8 | 29.21 |
| ι Piscium | W. | | 42 | 14.38 | +0.03 | −0.08 | − 0,40 | | 42 | 13,93 | 23 | 33 | 44.78 | 8 | 29.15 |
| γ Cephei | W. | | 42 | 57.43 | +0.10 | +0,53 | − 1,75 | | 42 | 56,31 | 23 | 34 | 27.08 | 8 | 29.23 |
| Groom. 4163 | W. | 23 | 57 | 30.75 | +0,09 | +0.40 | − 1.41 | 23 | 57 | 29,83 | 23 | 49 | 00.47 | 8 | 29.36 |
| ω Piscium | W. | 0 | 01 | 36.68 | +0.03 | −0.08 | − 0,40 | 0 | 01 | 36.23 | 23 | 53 | 07.08 | 8 | 29.15 |
| ε Andromedæ | E. | | 10 | 38.21 | −0.15 | −0.01 | + 0.45 | | 10 | 33,50 | 0 | 02 | 09.29 | 8 | 29.21 |
| 22 Andromedæ | E. | | 12 | 32.41 | −0.19 | +0.05 | + 0.56 | | 12 | 32.83 | 0 | 04 | 03.51 | 8 | 29.32 |
| γ Pegasi | E. | | 15 | 30,52 | −0.13 | −0.06 | + 0,41 | | 15 | 30.74 | 0 | 07 | 01.54 | 8 | 29.20 |
| δ B. Ursæ Minoris, s. p | E. | | 22 | 37.99 | +2.44 | −5.14 | −13.86 | | 22 | 21.43 | 0 | 13 | 50,86 | 8 | 30.57 |
| 12 Ceti | E. | | 32 | 22.24 | −0,11 | −0.10 | + 0.40 | | 32 | 22.43 | 0 | 23 | 53.12 | 8 | 29.31 |
| π Andromedæ | E. | 0 | 38 | 55.35 | −0.16 | 0.00 | + 0,47 | 0 | 38 | 55,66 | 0 | 30 | 26.49 | − 8 | 29.17 |

NORMAL EQUATIONS.

$$a_0 = -0^s.20 \qquad c_0 = +0^s.25 \qquad \Delta T_0 = -8^m\ 29^s.20 \text{ for } 0^h.0$$

$$\begin{aligned} &\quad\ \ s. \\ 0 &= -0.044 + 8.35\, d\Delta T + 1.42\, da + 1.32\, dc \\ 0 &= -0{,}917 + 1{,}42\, d\Delta T + 9.63\, da + 4.68\, dc \\ 0 &= -3{,}457 + 1.32\, d\Delta T + 4{,}68\, da + 23.30\, dc \end{aligned}$$

$$\begin{aligned} & \qquad\quad s. & & \qquad\quad m.\ \ s. \\ d\Delta T &= -0.022 & \Delta T &= -8\ 29.222\ (\text{wt.} = 8.12) \\ da &= +0.029 & a &= -\ \ 0.171\ (\text{wt.} = 8.54) \\ dc &= +0.144 & c &= +\ \ 0.394\ (\text{wt.} = 20.98) \end{aligned}$$

*Ogden, September 26, 1878; before signals.*

| Name of star. | Clamp. | T. | | | B*b*. | A*a*. | C*c*. | T′. | | | A. R. | | | Δ T. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| 50 Draconis | E. | 18 | 52 | 50.79 | +0.16 | −0.30 | +0.94 | 18 | 52 | 51.59 | 18 | 50 | 16.61 | −2 | 34.98 |
| γ Lyræ | E. | 18 | 56 | 59.80 | +0.06 | +0.02 | +0.28 | 18 | 57 | 00.16 | 18 | 54 | 25.23 | 2 | 34.93 |
| ζ Aquilæ | E. | 19 | 02 | 25.83 | +0.03 | +0.06 | +0.25 | 19 | 02 | 26.17 | 18 | 59 | 51.11 | 2 | 35.06 |
| ι Lyræ | E. | | 05 | 33.89 | +0.02 | +0.02 | +0.30 | | 05 | 34.23 | 19 | 02 | 59.26 | 2 | 34.97 |
| 19 Lyræ | E. | | 09 | 42.43 | +0.01 | +0.03 | +0.28 | | 09 | 42.75 | 19 | 07 | 07.78 | 2 | 34.97 |
| δ Draconis | E. | | 15 | 06.30 | −0.02 | −0.16 | +0.63 | | 15 | 06.75 | 19 | 12 | 31.83 | 2 | 34.92 |
| φ Cygni | W. | | 37 | 11.45 | −0.09 | +0.03 | −0.28 | | 37 | 11.11 | 19 | 34 | 36.12 | 2 | 34.99 |
| 28 Heis Cygni | W. | | 40 | 40.79 | −0.09 | +0.03 | −0.28 | | 40 | 40.45 | 19 | 38 | 05.53 | 2 | 34.92 |
| δ Sagittæ | W. | | 44 | 35.21 | −0.07 | +0.06 | −0.25 | | 44 | 34.95 | 19 | 42 | 00.04 | 2 | 34.91 |
| 12 Vulpeculæ | W. | | 48 | 27.12 | −0.08 | +0.05 | −0.26 | | 48 | 26.83 | 19 | 45 | 51.80 | 2 | 35.03 |
| ε Draconis | W. | | 51 | 11.49 | −0.19 | −0.19 | −0.70 | | 51 | 10.41 | 19 | 48 | 35.37 | 2 | 35.04 |
| γ Sagittæ | W. | 19 | 55 | 58.21 | −0.07 | +0.05 | −0.25 | 19 | 55 | 57.94 | 19 | 53 | 22.99 | −2 | 34.95 |

NORMAL EQUATIONS.

$$a_0 = +\ 0^s.15 \qquad c_0 = +\ 0^s.25 \qquad \Delta T_0 = -\ 2^m\ 34^s.98 \text{ for } 19^h.5$$

$$\begin{aligned} &\quad\ \ \, s. \\ 0 &= -\ 0.078 + 9.50\, d\Delta T + 0.92\, da - \ \ 0.02\, dc \\ 0 &= +\ 0.014 + 0.92\, d\Delta T + 3.22\, da - \ \ 2.39\, dc \\ 0 &= +\ 0.177 - 0.02\, d\Delta T - 2.39\, da + 20.36\, dc \end{aligned}$$

$$\begin{aligned} &\qquad\quad s. & &\qquad\ \ m.\ \ s. \\ \Delta T &= +\ 0.010 & \Delta T &= -\ 2\ 34.97 \ \ (\text{wt.} = \ \ 9.21) \\ da &= -\ 0.015 & a &= +\ \ \ \ 0.135 \ (\text{wt.} = \ \ 2.85) \\ dc &= -\ 0.010 & c &= +\ \ \ \ 0.240 \ (\text{wt.} = 18.54) \end{aligned}$$

*Ogden, September 26, 1878; after signals.*

| Name of star. | Clamp. | T. | | | B*b*. | A*a*. | C*c*. | T′. | | | A. R. | | | ΔT. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| η Pegasi | W. | 22 | 39 | 55.65 | −0.02 | +0.09 | −0.25 | 22 | 39 | 55.47 | 22 | 37 | 20.94 | −2 | 34.53 |
| λ Pegasi | W. | | 43 | 18.06 | −0.02 | +0.14 | −0.25 | | 43 | 17.93 | 22 | 40 | 43.22 | 2 | 34.71 |
| ι Cephei | W. | 22 | 47 | 59.98 | −0.04 | −0.40 | −0.53 | 22 | 47 | 59.01 | 22 | 45 | 24.33 | 2 | 34.68 |
| β Pegasi | W. | 23 | 00 | 30.41 | −0.02 | +0.11 | −0.25 | 23 | 00 | 30.25 | 22 | 57 | 55.62 | 2 | 34.63 |
| 56 Pegasi | W. | | 03 | 49.19 | −0.02 | +0.12 | −0.24 | | 03 | 49.05 | 23 | 01 | 14.30 | 2 | 34.75 |
| π Cephei | W. | 23 | 06 | 42.34 | −0.05 | −0.84 | −0.84 | 23 | 06 | 40.61 | 23 | 04 | 05.95 | −2 | 34.66 |

NORMAL EQUATIONS.

$$a_0 = +0^s.40 \qquad c = +0^s.22 \qquad \Delta T_0 = -2^m\ 34^s.65 \text{ for } 22^h.8$$

$$\begin{aligned} 0 &= \overset{s.}{+0.038} + 4.49\,d\Delta T + 0.12\,da \\ 0 &= \phantom{+}0.000 + 0.12\,d\Delta T + 1.86\,da \end{aligned}$$

$$\begin{aligned} d\Delta T &= \overset{s.}{-0.008} \quad \Delta T = -\overset{m.}{2}\ \overset{s.}{34.658} \text{ (wt. = 4.48)} \\ da &= +0.001 \quad a = +\ 0.401 \text{ (wt. = 1.86)} \end{aligned}$$

The value of *c* was obtained from other nights' work and the previous observations of this night; it clouded up after reversal.

*Ogden, September 27, 1878; before signals.*

| Name of star. | Clamp. | T. | Bb. | Aa. | Cc. | T.′ | A. R. | Δ T. |
|---|---|---|---|---|---|---|---|---|
| | | h. m. s. | s. | s. | s. | h. m. s. | h. m. s. | m. s. |
| φ Cygni | E. | 19 37 09.49 | + 0.02 | + 0.06 | + 0.26 | 19 37 9.82 | 19 34 36.11 | −2 33.71 |
| 28 Heis Cygni | E. | 40 38.87 | + 0.02 | + 0.05 | + 0.25 | 40 39.19 | 19 38 05.51 | 2 33.68 |
| δ Sagittæ | E. | 44 33.28 | + 0.02 | + 0.11 | + 0.23 | 44 33.64 | 19 42 00.02 | 2 33.62 |
| 12 Vulpeculæ | E. | 48 25.13 | + 0.02 | + 0.09 | + 0 23 | 48 25.47 | 19 45 51.78 | 2 33.69 |
| ε Draconis | E. | 51 08.51 | + 0.05 | − 0.37 | + 0.63 | 51 08.82 | 19 48 35.31 | 2 33.51 |
| γ Sagittæ | E. | 19 55 56.34 | + 0.02 | + 0.10 | + 0.23 | 19 55 56.69 | 19 53 22.98 | 2 33.71 |
| κ Cephei | W. | 20 15 33.08 | − 0.01 | − 0.71 | − 0.98 | 20 15 31.38 | 20 12 57.68 | 2 33.70 |
| γ Cygni | W. | 20 27.60 | − 0.01 | + 0.01 | − 0.28 | 20 27.32 | 20 17 53.73 | 2 33.59 |
| 40 Cygni | W. | 25 39.61 | − 0.01 | + 0.02 | − 0.27 | 25 39.35 | 20 23 05.89 | 2 33.46 |
| ε Delphini | W. | 30 00.27 | 0.00 | + 0.13 | − 0.22 | 30 00.18 | 20 27 26.47 | 2 33.71 |
| 73 Draconis | W. | 35 41.94 | − 0.01 | − 0.54 | − 0.81 | 35 40.58 | 20 33 06.70 | 2 33.88 |
| Pi. XX. 283 | W. | 20 40 12.48 | 0.00 | + 0.03 | − 0.26 | 20 40 12.25 | 20 37 38.54 | −2 33.71 |

NORMAL EQUATIONS.

$a_0 = +0^s.25 \qquad c_0 + 0^s.20 \qquad \Delta T_0 = -2^m 33^s.65$ for $20^h.0$

$$\begin{aligned} & \quad\ \ s. \\ 0 &= +0.168 + 9.19\,d\Delta T + 0.73\,da + 0.23\,dc \\ 0 &= -0.074 + 0.73\,d\Delta T + 3.87\,da + 3.48\,dc \\ 0 &= -0.354 + 0.23\,d\Delta T + 3.48\,da + 21.40\,dc \end{aligned}$$

$$\begin{aligned} & \quad\ \ s. & & \quad\ \ m. \quad s. \\ d\Delta T &= -0.019 & \Delta T &= -2 \quad 33.669 \text{ (wt.} = 9.05) \\ da &= +0.009 & a &= + \quad 0.259 \text{ (wt.} = 3.49) \\ dc &= +0.015 & c &= + \quad 0.215 \text{ (wt.} = 19.57) \end{aligned}$$

*Ogden, September 27,* 1878; *after signals.*

| Name of star. | Clamp. | T. | B *b*. | A *a*. | C *c*. | T′. | A. R. | Δ T. |
|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *h. m. s.* | *m. s.* |
| 226 Cephei B | W. | 22 32 45.94 | + 0.18 | − 0.57 | − 0.70 | 22 32 44.85 | 22 30 11.48 | − 2 33.37 |
| μ Pegasi | W. | 46 44.37 | + 0.06 | + 0.08 | − 0.19 | 46 44.32 | 22 44 10.81 | 2 33.51 |
| B. A. C. 7984 | W. | 51 08.83 | + 0.07 | + 0.01 | − 0.23 | 51 08.68 | 22 48 34.95 | 2 33.73 |
| Pl. XXII. 261 | W. | 22 54 40.21 | + 0.07 | − 0.17 | + 0.01 | 22 54 40.12 | 22 | .............. |
| β Pegasi | W. | 23 00 29.23 | + 0.06 | + 0.07 | − 0.20 | 23 00 29.16 | 22 57 55.62 | 2 33.54 |
| 56 Pegasi | W. | 03 47.74 | + 0.06 | + 0.08 | − 0.19 | 03 47.69 | 23 01 14.30 | 2 33.39 |
| π Cephei | E. | 06 39.22 | + 0.14 | − 0.53 | + 0.66 | 06 39.49 | 23 04 05.93 | 2 33.56 |
| τ Pegasi | E. | 17 13.24 | + 0.04 | + 0.09 | + 0.19 | 17 13.56 | 23 14 40.00 | 2 33.56 |
| υ Pegasi | E. | 21 54.76 | + 0.04 | + 0.09 | + 0.19 | 21 55.08 | 23 19 21.56 | 2 33.52 |
| 70 Pegasi | E. | 25 36.54 | + 0.04 | + 0.13 | + 0.18 | 25 36.89 | 23 23 03.21 | 2 33.68 |
| 72 Pegasi | E. | 23 30 31.31 | + 0.05 | + 0.05 | + 0.20 | 23 30 31.61 | 23 27 58.22 | − 2 33.39 |

NORMAL EQUATIONS.

$a_0 = +0^s.25 \quad c_0 = +0^s.20 \quad \Delta T_0 = -2^m\,33^s.54$ for $23^h.0$

$$
\begin{aligned}
&\phantom{0 = -}\,s.\\
0 &= -0.037 + 8.01\,d\Delta T + 1.23\,da - 0.07\,dc\\
0 &= -0.001 + 1.23\,d\Delta T + 2.99\,da + 0.54\,dc\\
0 &= +0.436 - 0.07\,d\Delta T + 0.54\,da + 16.61\,dc
\end{aligned}
$$

$$
\begin{aligned}
d\Delta T &= +0^s.004 & \Delta T &= -2^m\ 33^s.536 \ (\text{wt.} = 7.50)\\
da &= +0.003 & a &= +\ 0.253 \ (\text{wt.} = 2.78)\\
dc &= -0.026 & c &= +\ 0.174 \ (\text{wt.} = 16.50)
\end{aligned}
$$

*Ogden, September 30, 1878; before signals.*

| Name of star. | Clamp. | T. | | | B *b*. | A *a*. | C *c*. | T′. | | | A. R. | | | Δ T. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| 28 Heis Cygni | W. | 19 | 40 | 34.07 | + 0.02 | + 0.07 | − 0.29 | 19 | 40 | 33 87 | 19 | 38 | 05.45 | − 2 | 28.42 |
| δ Sagittæ | W. | | 44 | 28.39 | + 0.02 | + 0.15 | − 0.26 | | 44 | 28.30 | 19 | 41 | 59.96 | 2 | 28.34 |
| 12 Vulpeculæ | W. | | 48 | 20.15 | + 0.02 | + 0.13 | − 0.26 | | 48 | 20.04 | 19 | 45 | 51.78 | 2 | 28.31 |
| 15 Vulpeculæ | W. | 19 | 58 | 35.81 | + 0.02 | + 0.10 | − 0.28 | 19 | 58 | 35.65 | 19 | 56 | 07.36 | 2 | 28.29 |
| η Sagittæ | W. | 20 | 02 | 16.38 | + 0.02 | + 0.15 | − 0.26 | 20 | 02 | 16.29 | 19 | 59 | 47.89 | 2 | 28.40 |
| κ Cephei | W. | | 15 | 28.15 | + 0.08 | − 1.01 | − 1.11 | | 15 | 26.11 | 20 | 12 | 57.39 | 2 | 28.72 |
| ε Delphini | E. | | 29 | 54.54 | − 0.04 | + 0.19 | + 0.25 | | 29 | 54.94 | 20 | 27 | 26.43 | 2 | 28.51 |
| 73 Draconis | E. | | 35 | 35.06 | − 0.15 | − 0.78 | + 0.91 | | 35 | 35.04 | 20 | 33 | 06.52 | 2 | 28.52 |
| ε Cygni | E. | | 43 | 47.62 | − 0.06 | + 0.06 | + 0.29 | | 43 | 47.91 | 20 | 41 | 19.54 | 2 | 28.37 |
| Pl. XX., 358 | E. | | 48 | 48.55 | − 0.05 | + 0.10 | + 0.27 | | 48 | 48.87 | | | | | |
| 32 Vulpeculæ | E. | | 51 | 58.07 | − 0.05 | + 0.10 | + 0.27 | | 51 | 58.39 | 20 | 49 | 24.85 | 2 | 28.54 |
| Br. 2749 | E. | 20 | 55 | 32.09 | − 0.22 | − 1.37 | + 1.41 | 20 | 55 | 31.91 | 20 | 58 | 04.00 | − 2 | 27.91 |

NORMAL EQUATIONS.

$$a_0 = +0^s.40 \qquad c_0 = +0^s.25 \qquad \Delta T_0 = -2^m\,28^s.42 \text{ for } 20^h.0$$

$$\begin{aligned} &\quad\; s. \\ 0 &= -0.120 + 8.16\, d\Delta T + 1.03\, da - 1.29\, dc \\ 0 &= +0.079 + 1.08\, d\Delta T + 4.79\, da - 2.90\, dc \\ 0 &= +0.099 - 1.29\, d\Delta T - 2.90\, da + 20.49\, dc \end{aligned}$$

$$\begin{aligned} &\quad\; s. & &\quad\; m. \quad s. \\ d\Delta T &= +0.019 & \Delta T &= -2 \quad 28.401 \text{ (wt.} = 7.92) \\ da &= -0.024 & a &= + \quad 0.376 \text{ (wt.} = 4.29) \\ dc &= -0.007 & c &= + \quad 0.243 \text{ (wt.} = 18.66) \end{aligned}$$

*Ogden, September 30, 1878; after signals.*

| Name of star. | Clamp. | T. | B*b*. | A*a*. | C*c*. | T′. | A. R. | Δ T. |
|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *h. m. s.* | *m. s.* |
| 72 Pegasi | E. | 23 30 25.89 | + 0.03 | + 0.09 | + 0.26 | 23 30 26.27 | 23 27 58.22 | − 2 28.05 |
| γ Cephei | E. | 23 36 55.19 | + 0.08 | − 1.11 | + 0.97 | 23 36 55.13 | 23 34 26.99 | 2 28.14 |
| α Andromedæ | E. | 0 04 36.87 | + 0.02 | + 0.11 | + 0.25 | 0 04 37.25 | 00 02 09.24 | 2 28.01 |
| γ Pegasi | E. | 0 09 29.31 | + 0.02 | + 0.20 | + 0.23 | 0 09 29.76 | 00 07 01.52 | − 2 28.24 |

NORMAL EQUATIONS.

$a_0 = +0^s.37 \qquad c = +0^s.22 \qquad \Delta T_0 = -2^m\ 28^s.10$ for $0^h.0$

$$\begin{array}{l} \phantom{0 = -\ }\overset{s.}{} \\ 0 = -\ 0.033 + 3.04\ d\Delta T + 0.41\ da \\ 0 = -\ 0.095 + 0.41\ d\Delta T + 1.58\ da \end{array}$$

$$\begin{array}{rlrl} & \phantom{+}\ s. & & m.\ \ s. \\ d\Delta T = & +0.003 & \Delta T = & -2\ 28.097 \\ da = & +0.059 & a = & +\ \ \ \ 0.429 \end{array}$$

The value of *c* was obtained by combining the value obtained before signals with the general mean for previous and following nights.

*Ogden, October 1, 1878; before signals.*

| Name of star. | Clamp. | T. | Bb. | Aa. | Cc. | T′. | A. R. | |
|---|---|---|---|---|---|---|---|---|
| | | *h. m. s.* | *s.* | *s.* | *s.* | *h. m. s.* | *h. m. s.* | *m. s.* |
| 9 Cygni | E. | 19 32 28.85 | + 0.06 | + 0.10 | + 0.25 | 19 32 29.26 | 19 30 02.59 | − 2 26.67 |
| ϕ Cygni | E. | 37 02.30 | + 0.05 | + 0.09 | + 0.25 | 37 02.69 | 19 34 36.03 | 2 26.66 |
| 28 Heis Cygni | E. | 40 31.76 | + 0.05 | + 0.08 | + 0.26 | 40 32.15 | 19 38 05.43 | 2 26.72 |
| δ Sagittæ | E. | 44 26.18 | + 0.03 | + 0.17 | + 0.23 | 44 26.61 | 19 41 59.95 | 2 26.66 |
| ε Draconis | E. | 19 51 01.52 | + 0.03 | − 0.59 | + 0.64 | 19 51 01.60 | 19 48 35.06 | 2 26.54 |
| ρ Aquilæ | W. | 20 11 07.84 | − 0.04 | + 0.19 | − 0.23 | 20 11 07.76 | 20 08 41.09 | 2 26.67 |
| κ Cephei | W. | 15 26.33 | − 0.17 | − 1.13 | − 1.00 | 15 24.03 | 20 12 57.29 | 2 26.74 |
| 39 Cygni | W. | 21 28.99 | − 0.05 | + 0.08 | − 0.26 | 21 28.76 | 20 19 02.17 | 2 26.59 |
| 41 Cygni | W. | 26 54.27 | − 0.05 | + 0.09 | − 0.25 | 26 54.06 | 20 24 27.60 | 2 26.46 |
| ε Delphini | W. | 29 53.19 | − 0.04 | + 0.22 | − 0.22 | 29 53.15 | 20 27 26.41 | 2 26.74 |
| 73 Draconis | W. | 20 35 34.95 | − 0.14 | − 0.86 | − 0.82 | 20 35 33.13 | 20 33 06.40 | − 2 26.73 |

NORMAL EQUATIONS.

$a_0 = +0^s.50 \qquad c_0 = +0^s.20 \qquad \Delta T_0 = -2^m\ 26^s.65$ for $20^h.0$

$$0 = +0.065 + 8.38\, d\Delta T + 0.85\, da - 0.61\, dc$$
$$0 = +0.277 + 0.85\, d\Delta T + 3.92\, da + 2.30\, dc$$
$$0 = -0.171 - 0.61\, d\Delta T + 2.30\, da + 19.76\, dc$$

$d\Delta T = +\overset{s}{0}.002 \qquad \Delta T = -\overset{m}{2}\ \overset{s}{26}.648$ (wt. = 8.13)

$da = -0.081 \qquad a = +\ 0.419$ (wt. = 3.55)

$dc = +0.018 \qquad c = +\ 0.218$ (wt. = 18.26)

*Ogden, October 1, 1878; after signals.*

| Name of star. | Clamp. | T. | | | B*b*. | A*a*. | C*c*. | T′. | | | A. R. | | | ΔT. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| τ Pegasi | W. | 23 | 17 | 06.24 | 0.00 | + 0.19 | − 0.14 | 23 | 17 | 06.29 | 23 | 14 | 40.03 | − 2 | 26.26 |
| υ Pegasi | W. | | 21 | 47.88 | 0.00 | + 0.20 | − 0.14 | | 21 | 47.94 | 23 | 19 | 21.56 | 2 | 26.38 |
| 72 Pegasi | W. | | 30 | 24.60 | 0.00 | + 0.12 | − 0.15 | | 30 | 24.57 | 23 | 27 | 58.22 | 2 | 26.35 |
| 153 Heis Pegasi | W. | | 32 | 58.12 | 0.00 | | | | | | | | | | |
| γ Cephei | W. | | 36 | 55.46 | 0.00 | − 1.48 | − 0.55 | | 36 | 53.43 | 23 | 34 | 26.98 | 2 | 26.45 |
| 41 H. Cephei | E. | | 44 | 36.71 | − 0.02 | − 0.64 | + 0.32 | | 44 | 36.37 | 23 | 42 | 10.66 | 2 | 26.31 |
| ψ Pegasi | E. | | 54 | 02.82 | − 0.01 | + 0.18 | + 0.14 | | 54 | 03.13 | 23 | 51 | 36.85 | 2 | 26.28 |
| 85 Pegasi | E. | 23 | 58 | 18.32 | − 0.01 | + 0.16 | + 0.14 | 23 | 58 | 18.61 | 23 | 55 | 52.29 | 2 | 26.32 |
| α Andromedæ | E. | 0 | 04 | 35.36 | − 0.01 | + 0.14 | + 0.14 | 0 | 04 | 35.63 | 0 | 02 | 09.25 | 2 | 26.38 |
| γ Pegasi | E. | 0 | 09 | 27.63 | − 0.01 | + 0.27 | + 0.13 | 0 | 09 | 28.02 | 0 | 07 | 01.52 | − 2 | 26.50 |

NORMAL EQUATIONS.

$a_0 = +0^s.50 \qquad c_0 = +0^s.20 \qquad \Delta T_0 = -2^m.\ 26^s.35$ for $23^h.7$

$$
\begin{aligned}
&\overset{s.}{} \\
0 &= +0.057 + 7.29\, d\Delta T + 1.15\, da + 1.31\, dc \\
0 &= -0.078 + 1.15\, d\Delta T + 2.52\, da + 1.33\, dc \\
0 &= +1.011 + 1.31\, d\Delta T + 1.33\, da + 14.68\, dc
\end{aligned}
$$

$$
\begin{array}{rlrl}
 & \text{s.} & & \text{m. \quad s.} \\
d\Delta T = & -0.006 & \Delta T = & -2 \quad 26.356 \text{ (wt.} = 6.73) \\
da = & +0.078 & a = & + \quad 0.573 \text{ (wt.} = 2.25) \\
c = & -0.075 & c = & + \quad 0.125 \text{ (wt.} = 13.91)
\end{array}
$$

*Ogden, October 3, 1878; before signals.*

| Name of star. | Clamp. | T. | | | Bb. | Aa. | Co. | T′. | | | A. R. | | | ΔT. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | | |
| 9 Cygni | W. | 19 | 32 | 25.20 | − 0.02 | + 0.07 | 0.10 | 19 | 32 | 25.06 | 19 | 30 | 02.55 | − 2 | 22.51 |
| φ Cygni | W. | | 36 | 58.60 | 0.05 | + 0.07 | 0.19 | | 36 | 58.43 | 19 | 34 | 35.99 | 2 | 22.44 |
| 28 Heis Cygni | W. | | 40 | 28.09 | 0.06 | + 0.06 | 0.20 | | 40 | 27.80 | 19 | 38 | 05.38 | 2 | 22.51 |
| δ Sagittæ | W. | | 44 | 22.40 | 0.05 | + 0.13 | 0.18 | | 44 | 22.30 | 19 | 41 | 59.91 | 2 | 22.39 |
| ε Draconis | W. | 19 | 50 | 58.50 | 0.18 | 0.44 | 0.40 | 19 | 50 | 57.39 | 19 | 48 | 34.93 | 2 | 22.46 |
| ρ Aquilæ | E. | 20 | 11 | 03.27 | 0.06 | + 0.14 | + 0.17 | 20 | 11 | 03.52 | 20 | 08 | 41.05 | 2 | 22.47 |
| κ Cephei | E. | | 15 | 19.79 | 0.22 | − 0.84 | + 0.77 | | 15 | 19.50 | 20 | 12 | 57.09 | 2 | 22.41 |
| 39 Cygni | E. | | 21 | 24.34 | 0.07 | + 0.06 | + 0.20 | | 21 | 24.53 | 20 | 19 | 02.13 | 2 | 22.40 |
| 41 Cygni | E. | | 26 | 49.81 | 0.08 | + 0.07 | + 0.19 | | 26 | 49.99 | 20 | 24 | 27.57 | 2 | 22.42 |
| ε Delphini | E. | | 29 | 48.65 | 0.06 | + 0.16 | + 0.17 | | 29 | 48.92 | 20 | 27 | 26.38 | 2 | 22.54 |
| 73 Draconis | E. | 20 | 35 | 29.02 | 0.25 | − 0.65 | + 0.63 | 20 | 35 | 28.75 | 20 | 33 | 06.25 | − 2 | 22.50 |

NORMAL EQUATIONS.

$$a_0 = +0^{s}.40 \qquad c_0 = +0^{s}.20 \qquad \Delta T_0 = 2^{m}.22^{s}.46 \text{ for } 20^{h}.0$$

$$\begin{aligned}
&\phantom{=+}\,{}^{s.}\\
0 &= +0.099 + 8.38\, d\Delta T + 0.85\, da + 0.61\, dc\\
0 &= +0.273 + 0.85\, d\Delta T + 3.94\, da - 2.20\, dc\\
0 &= +0.430 + 0.61\, d\Delta T - 2.20\, da + 19.75\, dc
\end{aligned}$$

$$\begin{aligned}
& \phantom{=}\ \ {}^{s.} && \qquad\qquad\ {}^{m.}\quad {}^{s.}\\
d\Delta T &= -\,0.001 & \Delta T &= -\,2\quad 22.461\ (\text{wt.} = 8.13)\\
da &= -\,0.087 & a &= +\quad\ \ 0.313\ (\text{wt.} = 3.59)\\
dc &= -\,0.032 & c &= +\quad\ \ 0.168\ (\text{wt.} = 18.38)
\end{aligned}$$

*Ogden, October 3, 1878; after signals.*

| Name of star. | Clamp. | T. | | | Bb. | A a. | C c. | T′. | | | A. R. | | | ΔT. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *h.* | *m.* | *s.* | *s.* | *s.* | *s.* | *h.* | *m.* | *s.* | *h.* | *m.* | *s.* | *m.* | *s.* |
| ι Cephei | E. | 22 | 47 | 46.62 | + 0.15 | − 0.45 | + 0.45 | 22 | 47 | 46.77 | 22 | 45 | 24.21 | − 2 | 22.56 |
| β Pegasi | E. | 23 | 00 | 17.42 | + 0.03 | + 0.12 | + 0.21 | 23 | 00 | 17.78 | 22 | 57 | 55.00 | 2 | 22.18 |
| 56 Pegasi | E. | | 03 | 36.14 | + 0.02 | + 0.14 | + 0.20 | | 03 | 36.50 | 23 | 01 | 14.28 | 2 | 22.22 |
| Pi. XXIII. 4 | E. | | 07 | 05.10 | 0.00 | + 0.19 | + 0.19 | | 07 | 05.48 | 23 | 04 | 43.08 | 2 | 22.40 |
| ο Cephei | E. | | 16 | 03.82 | − 0.06 | 0.52 | + 0.48 | | 16 | 03.72 | 23 | 13 | 41.66 | 2 | 22.06 |
| 72 Pegasi | W. | | 30 | 20.60 | − 0.06 | + 0.10 | 0.22 | | 30 | 20.42 | 23 | 27 | 58.21 | 2 | 22.21 |
| γ Cephei | W. | | 36 | 51.38 | − 0.14 | − 1.17 | 0.82 | | 36 | 49.25 | 23 | 34 | 20.94 | 2 | 22.31 |
| 78 Pegasi | W. | | 40 | 18.10 | − 0.04 | + 0.11 | − 0.21 | | 40 | 17.96 | 23 | 37 | 55.57 | 2 | 22.39 |
| 79 Pegasi | W. | | 45 | 55.61 | − 0.04 | + 0.12 | − 0.21 | | 45 | 55.48 | 23 | 43 | 33.26 | 2 | 22.22 |
| φ Pegasi | W. | 23 | 48 | 43.53 | − 0.03 | + 0.18 | − 0.20 | 23 | 48 | 43.48 | 23 | 46 | 21.15 | 2 | 22.33 |

NORMAL EQUATIONS.

$a_0 = +0^s.40 \qquad c_0 = +0^s.20 \qquad \Delta T_0 = -2^m\ 22^s.27 \text{ for } 23^h.5$

$$
\begin{array}{l}
\quad\ \ s. \\
0 = +0.104 + 7.74\ d\Delta T + 0.50\ da + 0.31\ dc \\
0 = \ \ 0.154 + 0.59\ d\Delta T + 2.96\ da \quad 0.38\ dc \\
0 = +0.205 + 0.31\ d\Delta T \quad 0.38\ da + 17.55\ dc
\end{array}
$$

$$
\begin{array}{llll}
 & s. & & m.\quad s. \\
d\Delta T = & -0.017 & \Delta T = & -2\quad 22.287\ (\text{wt.} = 7.61) \\
da = & +0.053 & a = & +\quad 0.453\ (\text{wt.} = 2.91) \\
dc = & \ \ 0.014 & c = & +\quad 0.186\ (\text{wt.} = 17.50)
\end{array}
$$

FORM No. 12.

| Signals sent from— | Recorded at— | Mean of signals sent and received. | Time corrections. | Corrected time. | Difference of longitude. | Double wave time. | Means. |
|---|---|---|---|---|---|---|---|
| | | h. m. s. | h. m. s. | h. m. s. | m. s. | | m. s. |
| September 26: | | | | | | | |
| Ogden | Fort Bayard | 22 14 30.00 | − 2 34.75 | 22 11 55.25 | | 0.70 | 15 23.050 |
| | | 12 11 3.36 | +10 16 15.29 | 22 27 18.65 | 15 23.40 | | |
| Fort Bayard | Ogden | 22 22 18.63 | − 2 34.74 | 22 19 43.89 | | | |
| | | 12 18 50.00 | +10 16 16.59 | 22 35 06.59 | 15 22.70 | | |
| September 27: | | | | | | | |
| Ogden | Fort Bayard | 22 7 30.00 | − 2 33.56 | 22 4 56.44 | | 0.40 | 15 22.930 |
| | | 12 0 4.32 | +10 20 15.25 | 22 20 19.57 | 15 23.13 | | |
| Fort Bayard | Ogden | 22 14 7.04 | − 2 33.56 | 22 11 33.48 | | | |
| | | 12 6 40.00 | +10 20 16.21 | 22 26 56.21 | 15 22.73 | | |
| September 30: | | | | | | | |
| Ogden | Fort Bayard | 22 31 30.00 | − 2 28.21 | 22 29 1.79 | | 0.51 | 15 23.165 |
| | | 12 12 2.17 | +10 32 23.04 | 22 44 25.21 | 15 23.42 | | |
| Fort Bayard | Ogden | 22 54 22.15 | − 2 28.18 | 22 51 53.97 | | | |
| | | 12 34 50.00 | +10 32 26.88 | 23 7 16.88 | 15 22 91 | | |
| October 1: | | | | | | | |
| Ogden | Fort Bayard | 22 56 35.00 | − 2 26.42 | 22 54 8.58 | | 0.52 | 15 23.050 |
| | | 12 33 3.39 | +10 36 28.50 | 23 9 31.89 | 15 23.31 | | |
| Fort Bayard | Ogden | 23 2 43.16 | − 2 26.42 | 23 0 16.74 | | | |
| | | 12 39 10.00 | +10 36 29.53 | 23 15 39.53 | 15 22.79 | | |
| October 3: | | | | | | | |
| Ogden | Fort Bayard | 22 21 30.00 | − 2 22.32 | 22 19 7.68 | | 0.71 | 15 23.095 |
| | | 11 50 6.18 | +10 44 24.95 | 22 34 31.13 | 15 23.45 | | |
| Fort Bayard | Ogden | 22 31 26.16 | − 2 22.30 | 22 29 3.86 | | | |
| | | 12 0 0.00 | +10 44 26.60 | 22 44 26.60 | 15 22.74 | | |

Final difference of longitude: $15^m. 23^s.058 \pm 0^s.025$, or 3° 50′ 45″.87 ± 0″.38.

Subtracting this value from the longitude of Ogden as given in the quarto report, we find 108° 9′ 8″.77 for the longitude of Fort Bayard.

For the personal equation, see report on geographical position of Fort Bliss.

*Mean place of stars for 1878.0 used for the determination of latitude of Fort Bayard, N. Mex.*

| No. B. A. C. | Class. | R. A. | | Declination. | No. B. A. C. | Class. | R. A. | | Declination. |
|---|---|---|---|---|---|---|---|---|---|
| | | h. m. s. | | ° ' " | | | h. m. s. | | ° ' " |
| 6626 | A | 19 15 22 | | 49 20 37.6 | 7681 | C | 21 58 1 | | 44 3 45.0 |
| 6642 | B | 19 18 53 | | 16 42 5.2 | 7705 | B | 22 1 6 | | 44 25 17.8 |
| 6647 | B | 19 19 16 | | 16 43 10.7 | 7712 | A | 22 2 7 | | 21 6 34.9 |
| 1) | C | 19 21 57 | | 14 2 14.1 | 7723 | A | 22 4 3 | | 5 35 53.6 |
| 2) | C | 19 23 45 | | 14 20 47.2 | 7730 | B | 22 8 0 | | 60 9 22.0 |
| 6697 | A | 19 26 38 | | 51 28 13.4 | | | | | |
| 6723 | A | 19 31 10 | | 50 58 31.4 | 7777 | A | 22 10 39 | | 37 8 30.1 |
| | | | | | 7798 | A | 22 15 41 | | 27 42 50.3 |
| 6748 | B | 19 35 57 | | 54 41 15.8 | | | | | |
| 6772 | AA | 19 40 28 | | 10 19 1.9 | 7814 | A | 22 19 3 | 14) | 0 45 32.0 |
| | | | | | 7837 | B | 22 23 10 | | 64 30 37.3 |
| 6783 | B | 19 41 57 | 12) | 18 14 4.0 | | | | | |
| 6799 | C | 19 43 53 | | 47 36 24.6 | 8) | B | 22 34 03 | 18) | 36 57 28.6 |
| | | | | | 7914 | A | 22 36 2 | | 28 40 16.2 |
| 6833 | AA | 19 49 19 | 13) | 6 6 11.6 | | | | | |
| 6852 | B | 19 51 24 | | 59 23 10.4 | 7932 | A | 22 38 39 | | 41 10 45.4 |
| | | | | | 7958 | A | 22 44 7 | | 23 57 28.0 |
| 6867 | C | 19 53 36 | | 58 31 14.8 | 8023 | A | 22 56 19 | | 41 40 14.0 |
| 6893 | A | 19 58 11 | 14) | 6 56 5.2 | | | | | |
| | | | | | 8071 | A | 23 3 53 | | 9 9 39.6 |
| 6926 | A | 20 2 16 | | 67 31 32.5 | 8083 | A | 23 7 25 | | 56 29 41.4 |
| 6934 | A | 20 5 1 | 15) | — 1 10 55.9 | | | | | |
| | | | | | 8131 | A | 23 14 36 | | 23 4 21.8 |
| 6966 | A | 20 10 6 | | 25 13 13.8 | 8160 | A | 23 19 17 | | 22 43 57.4 |
| 6986 | B | 20 12 35 | | 39 59 18.0 | 8229 | A | 23 32 9 | | 42 35 33.8 |
| 6996 | B | 20 13 48 | | 40 21 8.5 | | | | | |
| 7022 | A | 20 17 51 | | 39 52 1.3 | 8243 | A | 23 35 49 | 19) | 1 6 31.5 |
| 3) | C | 20 26 45 | | 25 23 39.2 | 9) | C | 23 36 36 | 17) | 63 50 20.2 |
| 7146 | A | 20 33 25 | | 15 24 38.8 | 8300 | A | 23 46 24 | | 10 16 7.4 |
| 7149 | AA | 20 33 58 | | 15 28 57.9 | 8322 | C | 23 51 0 | | 55 1 38.0 |
| 7182 | A | 20 38 27 | | 49 54 8.6 | 8330 | B | 23 52 50 | | 55 4 32.8 |
| 7200 | A | 20 41 0 | | 15 41 8.6 | | | | | |
| | | | | | 8 | B | 0 2 45 | | 17 32 1.5 |
| 7220 | A | 20 42 48 | | 61 21 54.8 | 10) | C | 0 5 36 | | 47 28 22.2 |
| 7255 | A | 20 49 34 | 16) | 4 4 4.1 | | | | | |
| | | | | | 58 | A | 0 11 57 | | 36 6 31.4 |
| 7275 | A | 20 52 49 | | 21 51 18.1 | 109 | A | 0 23 41 | | 29 4 43.2 |
| 7290 | A | 20 53 57 | | 43 59 48.0 | | | | | |
| 7333 | A | 21 0 30 | | 43 26 30.3 | 142 | B | 0 28 36 | | 12 42 1.9 |
| 7356 | A | 21 5 2 | | 21 57 30.8 | 153 | A | 0 30 11 | | 53 13 30.6 |
| 4) | C | 21 11 47 | 17) | 43 43 44.3 | | | | | |
| 7402 | A | 21 13 54 | | 43 25 59.1 | 173 | A | 0 34 31 | | 38 47 19.5 |
| | | | | | 229 | A | 0 43 20 | | 27 2 44.3 |
| 7418 | AA | 21 16 27 | | 19 17 0.0 | | | | | |
| 5) | C | 21 16 55 | 17) | 46 12 37.9 | 201 | B | 0 38 21 | | 54 33 11.1 |
| 7455 | A | 21 20 51 | | 46 11 10.6 | 11) | C | 0 39 7 | 20) | 54 38 16.0 |
| 6) | C | 21 23 26 | | 46 1 49.8 | 213 | B | 0 40 40 | | 11 18 29.5 |
| 7480 | A | 21 24 57 | | 46 0 11.2 | | | | | |
| 7) | C | 21 25 7 | | 45 53 31.2 | 222 | A | 0 42 21 | 15) | 6 55 14.3 |
| | | | | | 244 | C | 0 47 46 | | 58 18 41.3 |
| 7544 | A | 21 35 24 | | 42 43 13.6 | 254 | B | 0 49 25 | | 58 31 17.3 |
| 7585 | A | 21 40 28 | | 22 23 13.7 | 288 | A | 0 56 37 | 13) | 7 13 58.4 |
| 7598 | A | 21 42 17 | | 48 44 43.8 | 334 | AA | 1 2 54 | | 34 58 24.2 |
| 7606 | A | 21 44 20 | | 16 43 8.6 | 345 | B | 1 4 23 | | 30 46 31.0 |

---

1) Sd. 939.
2) Sd 946.
3) 43* Heis Vulpeculæ.
4) Groom. 3420.
5) Groom. 3438.
6) Sd. 1318.
7) Sd. 1323.
8) 28 Heis Lacertæ.
9) Groom. 4130 = Dm. 63° 2038 C. S.
10) Groom. 9 = Sd. 1735.
11) Groom. 137 = Pi. 0.168.
12) This star's declination has been corrected by —0."8 by the German Society's new catalogue depending upon newer observations; it will now be classed A.
13) Declination from mean of G. and B.
14) Declination from B.
15) Declination from G.
16) Declination only approximate.
17) Declination only approximate from R. C.
18) Declination from Main 71 — 2 — 3; three observations which do not agree well.
19) From American Ephemeris for 1881, p. 336.
20) Position from a preliminary discussion.

## *Observations and computations for latitude, Fort Bayard, N. Mex.*

| Date. | Number of star. | Micrometer readings. | Level. N. | Level. S. | Half sum of declination. | Corrections. Micr. and refr. | Corrections. Level. | Corrections. Merid. | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | ° ′ ″ | ′ ″ | ″ | | ° ′ ″ |
| October 4, 1878 | ........ | 23.989 | 15.0 | 35.0 | 32 47 22.1 | + 0 19.4 | − 0.4 | ........ | 32 47 41.1 |
| | 6687 | 37.702 | 37.0 | 13.2 | | | | | |
| | 6723 | 9.025 | 32.0 | 18.4 | | | | | |
| | *a*6748 | 9.581 | 28.6 | 22.0 | 32 30 26.8 | +17 12.5 | − 2.9 | ........ | 36.4 |
| | *a*6772 | 43.823 | 17.0 | 33.0 | | | | | |
| | 6783 | 16.803 | 28.6 | 22.0 | 32 55 33.4 | − 7 49.4 | − 2.9 | ........ | 41.1 |
| | 6799 | 31.917 | 17.0 | 32.8 | | | | | |
| | 6833 | 21.475 | 25.6 | 25.4 | 32 44 59.2 | + 2 42.8 | + 0.4 | ........ | 42.4 |
| | 6852 | 26.715 | 26.0 | 25.0 | | | | | |
| | 6867 | 28.025 | 30.0 | 21.0 | 32 43 59.0 | + 3 45.3 | − 2.9 | ........ | 41.4 |
| | 6893 | 20.772 | 15.8 | 34.2 | | | | | |
| | 6966 | 39.055 | 27.8 | 22.8 | 32 34 48.4 | +12 53.6 | + 1.7 | ........ | 43.7 |
| | 6986 | 17.653 | 26.0 | 24.8 | | | | | |
| | 7022 | 10.642 | 25.2 | 25.4 | | | | | |
| | 7149 | 29.725 | 15.2 | 35.4 | 32 44 58.8 | + 2 44.6 | − 0.5 | ........ | 42.9 |
| | 7182 | 18.446 | 32.4 | 18.6 | | | | | |
| | *b*7200 | 17.762 | 30.8 | 20.6 | | | | | |
| | 7220 | 28.880 | 16.6 | 35.0 | 32 43 22.1 | + 4 19.9 | − 0.6 | ........ | 41.4 |
| | 7255 | 20.513 | 34.0 | 17.6 | | | | | |
| | 7275 | 24.556 | 31.2 | 20.6 | 32 46 19.9 | + 1 20.9 | − 2.5 | ........ | 38.3 |
| | 7290 | 8.558 | 17.0 | 35.0 | | | | | |
| | 7333 | 40.687 | 15.6 | 37.0 | | | | | |
| | *c*7356 | 30.510 | 31.8 | 20.6 | | | | | |
| | 7402 | 41.172 | 17.2 | 35.0 | | | | | |
| | 7418 | 33.453 | 15.6 | 36.6 | 32 41 46.2 | + 5 54.7 | + 0.7 | ........ | 41.6 |
| | 7455 | 27.352 | 38.0 | 14.4 | | | | | |
| | 7480 | 16.717 | 37.6 | 14.8 | | | | | |
| | 7544 | 11.517 | 13.2 | 38.0 | 32 33 40.4 | +13 58.7 | − 0.1 | ........ | 30.0 |
| | 7585 | 38.519 | 38.6 | 14.0 | | | | | |
| | 7598 | 27.046 | 35.8 | 16.0 | 32 44 22.9 | + 3 16.7 | + 4.1 | ........ | 43.7 |
| | 7606 | 20.714 | 23.0 | 29.6 | | | | | |
| | 7723 | 29.457 | 23.2 | 30.0 | 32 53 4.4 | − 5 25.2 | + 4.9 | ........ | 44.1 |
| | 7759 | 18.984 | 37.8 | 15.2 | | | | | |
| | 7814 | 34 945 | 22.6 | 31.4 | 32 38 31.2 | + 9 8.0 | + 1.3 | ........ | 40.5 |
| | 7837 | 17.302 | 33.4 | 20.4 | | | | | |
| | ........ | 26.762 | 38.6 | 15.4 | 32 49 21.2 | − 1 41.3 | + 4.0 | ........ | 43.9 |
| | 7914 | 23.501 | 21.8 | 32.2 | | | | | |
| | 7958 | 19.923 | 34.2 | 18.8 | 32 49 19.9 | − 1 37.7 | − 1.8 | ........ | 40.4 |
| | 8023 | 16.777 | 16.0 | 37.2 | | | | | |
| | 8071 | 23.637 | 24.4 | 28.6 | 32 50 9.0 | − 2 26.4 | − 0.7 | ........ | 41.9 |
| | 8083 | 28.349 | 27.4 | 25.6 | | | | | |
| | 8131 | 34.054 | 37.8 | 15.6 | 32 45 20.9 | + 2 19.7 | − 0.3 | ........ | 40.3 |
| | 8160 | 14.364 | 38.4 | 15.8 | | | | | |
| | 8229 | 28.708 | 15.6 | 39.0 | | | | | |
| | *d*8243 | 43.024 | 15.6 | 38.4 | 39 28 53.7 | +18 44.9 | 0.0 | ........ | 38.6 |
| | ........ | 6.808 | 16.0 | 38.0 | | | | | |
| | 8300 | 18.948 | 34.0 | 21.0 | 32 40 4.9 | + 7 35.7 | + 4.7 | ........ | 45.3 |
| | 8322 | 35.000 | 29.6 | 25.4 | | | | | |
| | 8330 | 32.238 | 27.4 | 27.4 | | | | | |
| | 8 | 42.892 | 31.8 | 24.2 | 32 30 40.6 | +16 58.3 | − 1.4 | ........ | 32 47 37.5 |
| | ........ | 10.108 | 22.0 | 34.0 | | | | | |

*a* Difference should be 33ʳ.242.
*b* I have assumed the level reading for 7200 = 20.6 N. 30.8 S.
*c* Possibly the middle point between 7354 and 7356 is taken; in this case add .3 to result.
*d* I suppose one level was misread; I don't know which.

*Observations and computations for latitude, Fort Bayard, N. Mex.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. | | Half sum of declination. | Corrections. | | | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
| | | | N. | S. | | Micr. and refr. | Level. | Merid. | |
| | | | | | ° ′ ″ | ′ ″ | ″ | | ° ′ ″ |
| October 4, 1878 ..... | 58 | 14.129 | 33.2 | 23.6 | 32 36 6.1 | +11 33.7 | − 1.6 | ........ | 32 47 38.2 |
| | 109 | 36.464 | 20.8 | 35.6 | | | | | |
| | 142 | 16.822 | 16.0 | 40.2 | 32 58 14.2 | −10 30.2 | − 0.1 | ........ | 43.9 |
| | 153 | 37.112 | 40.0 | 16.2 | | | | | |
| October 6, 1878 .... | 6748 | 9.965 | 27.0 | 24.0 | 32 30 26.9 | +17 10.6 | − 1.1 | ........ | 36.4 |
| | 6772 | 43.146 | 22.6 | 29.0 | | | | | |
| | 6833 | 28.762 | 20.0 | 31.6 | 32 44 59.3 | + 2 41.2 | − 0.7 | ........ | 39.8 |
| | 6852 | 23.571 | 30.6 | 21.2 | | | | | |
| | 6867 | 20.945 | 23.2 | 28.8 | 32 43 50.2 | + 3 41.8 | − 1.4 | ........ | 39.6 |
| | 6893 | 28.086 | 26.4 | 25.4 | | | | | |
| | 6966 | 11.648 | 24.6 | 36.8 | 32 41 40.1 | + 6 1.4 | − 0.9 | ........ | 40.6 |
| | 6986 | 33.055 | 31.2 | 21.0 | | | | | |
| | 6996 | 11.929 | 31.2 | 20.8 | | | | | |
| | 7022 | 40.018 | 33.0 | 19.0 | | | | | |
| | ........ | 21.749 | 18.8 | 34.8 | | | | | |
| | 7146 | 15.690 | ...... | ...... | 32 43 14.9 | + 4 26.0 | − 1.5 | ........ | 39.4 |
| | 7149 | 19.847 | 25.0 | 29.0 | | | | | |
| | 7182 | 30.930 | 26.8 | 27.6 | | | | | |
| | 7200 | 31.560 | 25.0 | 29.0 | | | | | |
| | 7220 | 20.440 | 41.2 | 13.6 | 32 43 22.3 | + 4 21.1 | + 2.8 | ........ | 46.2 |
| | 7255 | 28.847 | 17.8 | 36.4 | | | | | |
| | 7275 | 25.605 | 17.6 | 37.4 | 32 46 20.1 | + 1 22.1 | + 0.4 | ........ | 42.6 |
| | 7290 | 41.551 | 38.4 | 16.6 | | | | | |
| | 7333 | 9.429 | 44.0 | 11.0 | | | | | |
| | 7356 | 19.624 | 11.4 | 44.2 | | | | | |
| | 7402 | 8.931 | 39.6 | 11.6 | | | | | |
| | 7418 | 17.538 | 42.2 | 14.0 | 32 41 7.9 | + 6 33.0 | − 4.7 | ........ | 36.2 |
| | 7455 | 23.624 | 9.4 | 46.4 | | | | | |
| | ........ | 32.659 | | | | | | | |
| | 7480 | 34.288 | 3.0 | 52+ | | | | | |
| | 7544 | 38.439 | 32.2 | 24.6 | 32 33 40.7 | +13 59.9 | − 0.4 | ........ | 40.2 |
| | 7585 | 11.398 | 24.0 | 32.8 | | | | | |
| | 7598 | 22.904 | 33.0 | 24.0 | 32 44 23.1 | + 3 17.2 | − 6.9 | ........ | 33.4 |
| | 7606 | 29.252 | 12.6 | 44.4 | | | | | |
| | 7681 | 37.541 | 33.6 | 24.0 | 32 41 1.1 | + 6 40.8 | + 0.7 | ........ | 42.6 |
| | 7705 | 16.734 | 33.2 | 24.4 | | | | | |
| | 7712 | 14.234 | 25.4 | 32.4 | | | | | |
| | 7723 | 30.133 | 37.6 | 20.4 | 32 53 4.7 | − 5 21.8 | − 0.1 | ........ | 42.8 |
| | 7759 | 19.772 | 20.0 | 37.6 | | | | | |
| | 7777 | 46.605 | 22.2 | 35.6 | 32 26 13.3 | +21 25.6 | + 2.2 | ........ | 41.1 |
| | 779 | 5.214 | 39.2 | 18.6 | | | | | |
| | ........ | 27.653 | 39.4 | 18.6 | 32 49 21.6 | − 1 40.0 | − 5.4 | ........ | 36.2 |
| | 7914 | 24.434 | 9.8 | 48.0 | | | | | |
| | 7932 | 41.362 | 19.2 | 39.4 | 32 41 58.1 | + 5 40.9 | − 0.4 | ........ | 38.6 |
| | 7958 | 16.193 | 42.4 | 16.6 | | | | | |
| | 8023 | 12.978 | 12.6 | 46.4 | | | | | |
| | 8071 | 23.579 | 27.4 | 32.0 | 32 50 9.3 | − 2 27.8 | − 0.7 | ........ | 40.8 |
| | 8083 | 28.337 | 31.0 | 28.6 | | | | | |
| | 8131 | 33.769 | 39.0 | 20.4 | 32 45 21.3 | + 2 19.6 | − 4.4 | ........ | 36.5 |
| | 8160 | 13.967 | 34.0 | 25.4 | | | | | |
| | 8229 | 28.364 | 16.0 | 43.8 | | | | | |
| | 8 | 43.477 | 18.4 | 41.4 | 32 30 41.0 | +16 58.6 | − 3.8 | ........ | 35.8 |
| | ........ | 10.684 | 35.6 | 25.0 | | | | | |
| | 58 | 14.255 | 38.6 | 21.4 | 32 36 6.5 | +11 33.4 | − 6.4 | ........ | 32 47 33.5 |
| | 109 | 36.580 | 11.0 | 49.0 | | | | | |

*a* Level of 6966 in error; I have used a mean level for this group.

*Observations and computations for latitude, Fort Bayard, N. Mex.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. | | Half sum of declination. | Corrections. | | | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
| | | | N. | S. | | Micr. and refr. | Level. | Merid. | |
| | | | | | ° ′ ″ | ′ ″ | ″ | | ° ′ ″ |
| October 6, 1878..... | 142 | 17.186 | 25.6 | 34.0 | 32 58 14.6 | −10 30.9 | + 1.5 | ........ | 32 47 45.2 |
| | 153 | 37.500 | 37.0 | 23.6 | | | | | |
| | 173 | 33.765 | 29.2 | 30.4 | 32 55 30.5 | − 7 49.6 | + 1.1 | ........ | 42.0 |
| | 229 | 18.646 | 32.2 | 27.6 | | | | | |
| October 7, 1878..... | 6966 | 39.872 | 27.2 | 27.4 | 32 41 40.1 | + 6 2.0 | − 1.8 | ........ | 40.3 |
| | 6986 | 18.553 | 26.8 | 28.0 | | | | | |
| | 6996 | 39.634 | 25.8 | 29.0 | | | | | |
| | 7022 | 11.544 | 24.4 | 30.0 | | | | | |
| | ........ | 29.923 | 25.0 | 29.8 | | | | | |
| | 7146 | 34.517 | 19.6 | 35.4 | 32 43 15.0 | + 4 27.2 | − 2.9 | ........ | 39.3 |
| | 7149 | 30.346 | 19.2 | 35.8 | | | | | |
| | 7182 | 19.234 | 32.0 | 23.0 | | | | | |
| | 7200 | 18.648 | 16.0 | 39.0 | | | | | |
| | 7220 | 28.401 | 21.2 | 34.2 | 32 43 22.4 | + 4 8.6 | − 2.5 | ........ | 28.5 |
| | 7255 | 20.403 | 30.8 | 26.0 | | | | | |
| | 7275 | 24.975 | 33.2 | 22.4 | 32 47 7.6 | + 0 33.3 | − 1.8 | ........ | 39.1 |
| | 7290 | 8.938 | 22.4 | 33.6 | | | | | |
| | 7333 | 41.111 | 17.0 | 38.8 | | | | | |
| | 7356 | 30.955 | 35.0 | 20.8 | | | | | |
| | ........ | 24.480 | 19.8 | 36.6 | | | | | |
| | 7402 | 41.621 | 16.4 | 39.8 | | | | | |
| | 7418 | 33.029 | 28.6 | 27.8 | 32 40 52.1 | + 6 49.4 | − 1.4 | ........ | 40.1 |
| | ........ | 28.316 | 26.0 | 30.4 | | | | | |
| | 7455 | 26.907 | 26.2 | 30.4 | | | | | |
| | ....... | 17.881 | 24.0 | 32.4 | | | | | |
| | 7480 | 16.258 | 26.0 | 30.4 | | | | | |
| | ........ | 9.875 | | | | | | | |
| | 7544 | 11.666 | 38.2 | 18.8 | 32 33 40.8 | +14 1.9 | − 5.7 | ........ | 37.0 |
| | 7585 | 38.772 | 9.4 | 47.2 | | | | | |
| | 7598 | 27.430 | 26.0 | 30.8 | 32 44 23.3 | + 8 16.2 | + 1.2 | ........ | 40.7 |
| | 7006 | 21.112 | 32.6 | 24.0 | | | | | |
| | 7681 | 12.750 | 37.4 | 19.4 | 32 41 1.2 | + 6 41.7 | − 3.4 | ........ | 39.5 |
| | 7705 | 33.601 | 36.0 | 21.0 | | | | | |
| | 7712 | 36.142 | 14.6 | 42.0 | | | | | |
| | 7723 | 19.899 | 26.0 | 30.4 | 32 53 4.8 | − 5 24.0 | + 0.4 | ........ | 41.2 |
| | 7759 | 30.330 | 31.2 | 25.4 | | | | | |
| | 7777 | 3.949 | 31.0 | 26.0 | 32 26 13.4 | +21 29.9 | − 4.8 | ........ | 38.5 |
| | 7798 | 45.477 | 17.8 | 38.4 | | | | | |
| | 7814 | 35.212 | 24.8 | 32.0 | 32 38 31.6 | + 9 11.3 | + 0.4 | ........ | 43.3 |
| | 7837 | 17.465 | 32.6 | 24.0 | | | | | |
| | ........ | 26.316 | 30.0 | 27.0 | 32 49 21.7 | − 1 38.0 | − 6.6 | ........ | 37.1 |
| | 7914 | 23.160 | 16.6 | 41.0 | | | | | |
| | 7932 | 40.449 | 29.0 | 26.2 | 32 41 58.3 | + 5 45.9 | − 1.9 | ........ | 42.3 |
| | 7958 | 15.118 | 23.6 | 33.8 | | | | | |
| | 8023 | 12.058 | 31.8 | 26.2 | | | | | |
| | 8131 | 33.315 | 32.8 | 26.4 | 32 45 21.4 | + 2 20.8 | − 6.9 | ........ | 35.3 |
| | 8160 | 13.493 | 26.8 | 32.4 | | | | | |
| | 8229 | 27.938 | 18.4 | 41.2 | | | | | |
| | 8243 | 43.883 | 15.0 | 43.8 | 32 28 54.2 | +18 45.9 | − 4.1 | ........ | 36.0 |
| | ........ | 7.635 | 37.4 | 21.8 | | | | | |
| | 8300 | 18.661 | 30.8 | 28.4 | 32 40 5.5 | + 7 36.5 | − 2.5 | ........ | 39.5 |
| | 8322 | 34.753 | 26.0 | 33.2 | | | | | |
| | 8330 | 31.966 | 22.8 | 36.6 | | | | | |
| | 8 | 42.603 | 28.4 | 31.6 | 32 30 41.2 | +10 58.4 | − 1.5 | ........ | 38.1 |
| | ........ | 9.816 | 29.0 | 30.6 | | | | | |
| | 58 | 13.772 | 24.6 | 35.4 | 32 36 6.7 | +11 35.4 | + 0.1 | ........ | 32 47 42.2 |
| | 109 | 36.162 | 35.6 | 24.4 | | | | | |

*Observations and computations for latitude, Fort Bayard, N. Mex.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. |  | Half sum of declination. | Corrections. |  |  | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  | N. | S. |  | Micr. and refr. | Level. | Merid. |  |
|  |  |  |  |  | ° ′ ″ | ′ ″ | ″ |  | ° ′ ″ |
| October 7, 1878...... | 142 | 15.314 | 22.4 | 37.2 | 32 58 14.8 | —10 31.2 | — 1.7 | ........ | 32 47 41.9 |
|  | 153 | 35.637 | 34.6 | 25.4 |  |  |  |  |  |
|  | 173 | 33.690 | 34.2 | 25.2 | 32 55 30.7 | — 7 48.0 | — 4.7 | ........ | 38.0 |
|  | 229 | 18.621 | 17.4 | 41.6 |  |  |  |  |  |
| October 8, 1878...... | 6626 | 10.562 | 22.0 | 32.6 | 33 1 38.3 | —13 57.4 | + 2.5 | ........ | 43.4 |
|  | 6642 | 37.524 | 36.8 | 18.2 |  |  |  |  |  |
|  | ........ | *a*9.232 | 30.4 | 25.0 | 32 42 43.9 | + 4 53.2 | — 3.8 | ........ | 35.3 |
|  | ........ | 27.116 | 27.6 | 27.8 |  |  |  |  |  |
|  | 6687 | 13.337 | 21.8 | 34.0 |  |  |  |  |  |
|  | 6723 | 42.020 | 19.2 | 36.6 |  |  |  |  |  |
|  | 6748 | 41.006 | 32.0 | 24.4 | 32 30 26.9 | +17 12.4 | — 3.6 | ........ | 35.7 |
|  | 6772 | 7.767 | 18.8 | 38.0 |  |  |  |  |  |
|  | 6833 | 27.852 | 20.0 | 37.0 | 32 44 59.5 | + 2 41.8 | — 1.3 | ........ | 40.0 |
|  | 6852 | 22.643 | 35.0 | 22.2 |  |  |  |  |  |
|  | 6867 | 22.270 | 31.0 | 26.0 | 32 43 50.3 | + 3 43.8 | — 3.5 | ........ | 39.6 |
|  | 6893 | 29.477 | 20.6 | 36.8 |  |  |  |  |  |
|  | 6926 | 2.932 | 24.2 | 33.2 | 33 10 37.0 | —22 55.2 | — 1.8 | ........ | 40.0 |
|  | 6934 | 47.207 | (*b*) | (*b*) |  |  |  |  |  |
|  | 6966 | 10.532 | 30.0 | 27.4 | 32 41 40.2 | + 6 0.9 | + 1.0 | ........ | 42.1 |
|  | 6986 | 31.924 | 29.4 | 28.2 |  |  |  |  |  |
|  | 6996 | 10,715 | 34.0 | 23.6 |  |  |  |  |  |
|  | 7022 | 38.933 | 29.8 | 27.4 |  |  |  |  |  |
|  | ........ | 20.611 | 26.0 | 31.8 |  |  |  |  |  |
|  | 7146 | 15.384 | 31.2 | 26.8 | 32 43 15.1 | + 4 25.3 | — 1.8 | ........ | 38.6 |
|  | 7149 | 19.547 | 30.6 | 27.2 |  |  |  |  |  |
|  | 7182 | 30.636 | 22.6 | 35.2 |  |  |  |  |  |
|  | 7200 | 31.349 | 35.0 | 22.8 |  |  |  |  |  |
|  | 7220 | 21.462 | 37.0 | 20.6 | 32 43 22.5 | + 4 20.1 | — 3.5 | ........ | 39.1 |
|  | 7255 | 29.837 | 15.4 | 43.0 |  |  |  |  |  |
|  | 7275 | 25.993 | 32.8 | 26.0 | 32 46 20.4 | + 1 21.1 | — 1.9 | ........ | 39.6 |
|  | 7290 | 41.986 | 26.0 | 33.0 |  |  |  |  |  |
|  | 7333 | 9.776 | 23.0 | 36.2 |  |  |  |  |  |
|  | 7356 | 19.929 | 32.4 | 27.2 |  |  |  |  |  |
|  | 7402 | 9.283 | 21.8 | 38.0 |  |  |  |  |  |
|  | 7418 | 17.396 | 27.2 | 32.6 | 32 40 52.3 | + 6 53.0 | — 5.3 | ........ | 40.0 |
|  | ........ | 22.130 | 26.8 | 32.8 |  |  |  |  |  |
|  | 7455 | 23.564 | 23.4 | 36.2 |  |  |  |  |  |
|  | ........ | 32.538 | 25.4 | 34.2 |  |  |  |  |  |
|  | 7480 | *c*33.125 | ..... | ...... |  |  |  |  |  |
|  | ........ | 40.505 | 20.2 | 39.0 |  |  |  |  |  |
|  | 7544 | 38.903 | 24.4 | 35.0 | 32 33 41.0 | +14 1.1 | — 1.5 | ........ | 40.6 |
|  | 7585 | 11.822 | 32.6 | 27.0 |  |  |  |  |  |
|  | 7598 | 22.991 | 45.0 | 14.8 | 32 44 23.4 | + 3 17.5 | — 0.8 | ........ | 40.1 |
|  | 7606 | 29.350 | 13.6 | 46.4 |  |  |  |  |  |
|  | 7681 | 37.792 | 27.8 | 32.6 | 32 41 1.4 | + 6 40.0 | + 0.2 | ........ | 41.6 |
|  | 7705 | 16.967 | 28.0 | 32.4 |  |  |  |  |  |
|  | 7712 | 14.500 | 33.0 | 27.6 |  |  |  |  |  |
|  | 7723 | 29.759 | 32.6 | 27.8 | 32 53 5.0 | — 5 23.7 | — 1.9 | ........ | 39.4 |
|  | 7759 | 19.338 | 24.8 | 35.8 |  |  |  |  |  |
|  | 7777 | 45.682 | 25.0 | 35.8 | 32 26 13.6 | +21 25.3 | + 0.8 | ........ | 39.7 |
|  | 7798 | 4.300 | 37.2 | 23.8 |  |  |  |  |  |
|  | 7814 | *d*15.364 | 39.0 | 22.4 | 32 38 31.8 | + 9 8.9 | + 0.1 | ........ | 47 40.8 |
|  | 7837 | 32.036 | 22.8 | 39.0 |  |  |  |  |  |
|  | ....... | 24.514 | 20.0 | 41.2 | 32 49 21.9 | — 1 18.8 | — 0.1 | ........ | 32 48 3.0 |
|  | *e*7914 | 27.050 | 41.2 | 20.4 |  |  |  |  |  |

*a* $9^r.232$ used. *b* Missed. *c* Read $34^r.125$. *d* Micr. diff. $17^r.672$, not $16^r$. *e* Some mistake; I cannot tell what.

*Observations and computations for latitude, Fort Bayard, N. Mex.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. | | Half sum of declination. | Corrections. | | | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
| | | | N. | S. | | Micr. and refr. | Level. | Merid. | |
| | | | | | ° ′ ″ | ′ ″ | ″ | | ° ′ ″ |
| October 8, 1878 ..... | 7932 | 9.112 | 42.0 | 19.2 | 32 41 58.4 | + 5 43.7 | + 1.2 | ........ | 32 47 43.3 |
| | 7958 | 84.380 | 24.8 | 36.6 | | | | | |
| | 8023 | 37.514 | 35.0 | 26.6 | | | | | |
| | *a*8071 | 27.789 | 40.4 | 21.6 | 32 50 9.6 | − 2 28.0 | − 1.4 | ........ | 40.2 |
| | 8083 | 22.025 | 19.2 | 42.4 | | | | | |
| | 8131 | 16.916 | 22.8 | 38.8 | 32 45 21.6 | + 2 20.6 | − 3.0 | ........ | 39.2 |
| | 8160 | 36.554 | 24.4 | 37.2 | | | | | |
| | 8229 | 22.207 | 33.0 | 28.2 | | | | | |
| | 8243 | 6.594 | 23.0 | 38.0 | 32 28 54.4 | +18 47.8 | − 4.3 | ........ | 37.9 |
| | ........ | 42.903 | 26.0 | 25.0 | | | | | |
| | 8300 | 31.228 | 24.0 | 37.0 | 32 40 5.6 | + 7 36.0 | − 1.4 | ........ | 40.2 |
| | 8322 | 15.129 | 34.0 | 27.0 | | | | | |
| | 8330 | 17.966 | 35.6 | 25.6 | | | | | |
| | 8 | 6.900 | 37.0 | 24.6 | 32 30 41.4 | +16 58.9 | − 3.7 | ........ | 36.6 |
| | ........ | 39.703 | 18.6 | 42.8 | | | | | |
| | *b*58 | 36.993 | 26.2 | 35.0 | 32 36 6.9 | +11 34.5 | − 0.6 | ........ | 40.8 |
| | 109 | 13.634 | 34.0 | 27.2 | | | | | |
| | *c*142 | 38.854 | 35.2 | 26.4 | 32 58 15.0 | −10 35.0 | + 3.2 | ....... | 43.2 |
| | 153 | 13.409 | 31.4 | 30.0 | | | | | |
| | 201 | 16.142 | 31.0 | 30.2 | 32 57 35.0 | − 9 52.4 | + 1.6 | ........ | 44.2 |
| | ........ | 11.227 | 31.0 | 30.4 | | | | | |
| | 213 | 32.758 | 33.0 | 28.4 | | | | | |
| | 222 | 15.483 | 27.0 | 34.4 | 32 45 15.7 | + 2 25.0 | − 4.2 | ........ | 37.4 |
| | 244 | 35.285 | 22.0 | 39.2 | | | | | |
| | 254 | 23.183 | 22.6 | 38.6 | | | | | |
| | 288 | *d*13.588 | 37.8 | 24.4 | | | | | |
| | 334 | 26.041 | 31.0 | 31.4 | 32 52 56.0 | − 5 14.2 | − 0.7 | ........ | 41.1 |
| | 345 | 15.924 | 30.2 | 32.0 | | | | | |
| October 9, 1878 ..... | 6226 | 10.835 | 31.0 | 20.8 | 33 1 54.7 | −14 10.6 | − 1.8 | ........ | 42.3 |
| | 6642 | 37.679 | 18.2 | 34.0 | | | | | |
| | 6647 | 38.743 | 18.0 | 34.0 | | | | | |
| | ........ | 8.988 | 37.0 | 16.0 | 32 42 43.9 | + 4 53.0 | − 0.6 | ........ | 36.3 |
| | ........ | 26.919 | 35.6 | 17.0 | | | | | |
| | 6697 | 13.222 | 5.2 | 48.0 | | | | | |
| | 6723 | 41.553 | 26.4 | 27.2 | | | | | |
| | 6748 | 41.273 | 19.4 | 34.2 | 32 30 27.0 | +17 14.0 | − 2.4 | ........ | 38.6 |
| | 6772 | 7.983 | 30.6 | 23.4 | | | | | |
| | 6783 | 32.823 | 30.2 | 23.8 | 32 55 33.6 | − 7 48.7 | + 2.2 | ........ | 47.1 |
| | 6799 | 17.734 | 22.0 | 21.4 | | | | | |
| | 6833 | 28.312 | 17.8 | 36.4 | 32 44 50.5 | + 2 42.2 | − 2.2 | ........ | 39.5 |
| | 6852 | 23.089 | 33.0 | 21.4 | | | | | |
| | 6867 | 21.554 | 37.0 | 17.8 | 32 43 59.4 | + 3 42.7 | − 3.2 | ........ | 38.9 |
| | 6893 | 28.725 | 12.6 | 42.0 | | | | | |
| | 6926 | 2.918 | 28.6 | 26.4 | 33 10 37.1 | −22 52.9 | − 2.2 | ........ | 42.0 |
| | 6934 | 47.118 | 22.8 | 32.0 | | | | | |
| | 6966 | 11.077 | 29.2 | 25.6 | 32 41 40.3 | + 6 0.1 | − 2.0 | ........ | 38.4 |
| | 6986 | 32.533 | 20.0 | 35.0 | | | | | |
| | 6996 | 11.369 | 25.0 | 30.0 | | | | | |
| | 7022 | 39.444 | 24.0 | 31.4 | | | | | |
| | ........ | 21.300 | 29.0 | 27.0 | | | | | |
| | 7146 | 15.310 | 39.4 | 17.0 | 32 43 15.2 | + 4 27.2 | − 6.8 | ........ | 35.6 |
| | 7149 | 19.475 | 39.0 | 18.0 | | | | | |
| | 7182 | 30.613 | 3.0 | 53+ | | | | | |
| | 7200 | 31.248 | 49.6 | 7.0 | | | | | |
| | 7220 | 21.556 | 33.0 | 39.4 | 32 43 22.6 | + 4 20.5 | − 4.0 | ........ | 32 47 39.1 |
| | 7255 | 29.944 | 17.0 | 23.4 | | | | | |

*a* Micr. diff 4$^{r}$.764, not 5$^{r}$. *b* Micr. diff. 22$^{r}$.359, not 23$^{r}$. *c* Micr. diff .20$^{r}$.445, not 25$^{r}$. *d* Read 33$^{r}$.588, not 13$^{r}$.

*Observations and computations for latitude, Fort Bayard, N. Mex.*—Continued.

| Date. | Number of star. | Micrometer readings. | Level. | | Half sum of declination. | Corrections. | | | Latitude. |
|---|---|---|---|---|---|---|---|---|---|
| | | | N. | S. | | Micr. and refr. | Level. | Merid. | |
| | | | | | ° ′ ″ | ′ ″ | ″ | | ° ′ ″ |
| October 9, 1878 ..... | 7275 | 25.262 | 21.8 | 35.4 | 32 46 20.5 | + 1 22.9 | − 2.3 | ........ | 32 47 41.1 |
| | 7290 | 41.187 | 33.0 | 24.0 | | | | | |
| | 7333 | 9.044 | 32.0 | 25.0 | | | | | |
| | 7356 | 19.244 | 19.2 | 38.0 | | | | | |
| | 7402 | 8.522 | 34.0 | 23.4 | | | | | |
| | 7418 | 16.860 | 32.4 | 25.4 | 32 42 10.0 | + 5 31.3 | − 5.7 | ........ | 35.6 |
| | ........ | 21.529 | 18.4 | 39.0 | | | | | |
| | 7455 | [a]27.973 | 18.0 | 39.8 | | | | | |
| | ........ | 32.033 | 14.8 | 43.6 | | | | | |
| | 7480 | 33.595 | 13.4 | 44.4 | | | | | |
| | 7544 | 38.716 | 20.4 | 37.8 | 32 33 41.1 | +13 59.8 | + 0.6 | ........ | 41.5 |
| | 7585 | 11.677 | 39.0 | 19.6 | | | | | |
| | 7598 | 23.255 | 34.0 | 24.0 | 32 44 23.6 | + 3 19.0 | − 8.0 | ........ | 34.6 |
| | 7606 | 29.064 | 11.0 | 46.8 | | | | | |
| | 7681 | 37.350 | 30.0 | 27.8 | 32 41 1.5 | + 6 41.4 | − 0.8 | ........ | 42.1 |
| | 7705 | 16.514 | 31.4 | 26.8 | | | | | |
| | 7712 | 14.006 | 25.6 | 32.6 | | | | | |
| | 7723 | 30.705 | 42.8 | 15.6 | 32 53 5.1 | − 5 22.1 | − 2.7 | ........ | 40.3 |
| | 7759 | 20.334 | 11.0 | 47.0 | | | | | |
| | 7814 | 14.164 | 29.0 | 29.4 | 32 38 31.9 | + 9 8.8 | − 1.1 | ........ | 39.6 |
| | 7837 | 31.832 | 27.8 | 31.0 | | | | | |
| | ........ | 23.471 | 29.4 | 29.6 | 32 49 22.1 | − 1 37.6 | − 5.9 | ........ | 38.6 |
| | 7914 | 26.612 | 20.0 | 38.8 | | | | | |
| | 7932 | 10.415 | 43.4 | 15.6 | 32 41 58.6 | + 5 42.8 | − 0.2 | ........ | 41.2 |
| | 7958 | 35.671 | 15.0 | 43.6 | | | | | |
| | 8023 | 38.854 | 44.0 | 15.6 | | | | | |
| | 8071 | 27.114 | 28.2 | 31.6 | 32 50 9.8 | − 2 29.6 | − 0.4 | ........ | 39.8 |
| | 8083 | 22.298 | 31.0 | 28.8 | | | | | |
| | 8131 | 16.597 | 33.8 | 27.0 | 32 45 21.8 | + 2 19.8 | − 0.7 | ........ | 40.9 |
| | 8160 | 36.248 | 33.4 | 27.0 | | | | | |
| | 8229 | 21.922 | 26.0 | 35.0 | | | | | |
| | 8243 | 6.813 | 36.0 | 24.8 | 32 28 54.6 | +18 43.5 | + 1.3 | ........ | 39.4 |
| | ........ | 42.986 | 27.0 | 34.0 | | | | | |
| | 8300 | 81.425 | 15.8 | 45.0 | 32 40 5.8 | + 7 84.8 | − 0.1 | ........ | 40.5 |
| | 8322 | 15.339 | 45.0 | 16.0 | | | | | |
| | 8330 | 18.225 | | | | | | | |
| | 8 | 7.090 | 40.2 | 21.0 | 32 30 41.6 | +16 57.9 | − 5.3 | ........ | 34.2 |
| | ........ | 39.863 | 12.4 | 48.6 | | | | | |
| | 58 | 36.500 | 27.0 | 34.0 | 32 36 7.1 | +11 35.1 | − 1.1 | ........ | 41.1 |
| | 109 | 14.120 | 32.4 | 28.8 | | | | | |
| | 142 | 33.768 | 36.8 | 24.8 | 32 58 15.2 | −10 32.7 | + 2.4 | ........ | 44.9 |
| | 153 | 13.398 | 28.4 | 33.0 | | | | | |
| | 201 | 15.430 | 22.0 | 39.2 | 32 56 19.0 | − 8 35.6 | − 2.0 | ........ | 41.4 |
| | 213 | 32.080 | 86.0 | 25.4 | | | | | |
| | 244 | 34.764 | 27.8 | 33.6 | 32 49 56.9 | − 2 14.0 | − 1.3 | ....... | 41.6 |
| | 254 | 22.653 | 28.0 | 33.0 | | | | | |
| | 288 | 33.023 | 31.0 | 29.8 | | | | | |
| | 334 | 29.640 | 32.4 | 28.8 | 32 52 56.2 | − 5 12.9 | + 0.1 | ........ | 32 47 43.4 |
| | 345 | 19.567 | 29.0 | 32.2 | | | | | |

[a] Read 22$^{r}$.973.

*Discussion of latitude, Fort Bayard.*

| Combination. | Number of observations. | Number of stars. | Latitude. | Correction to microm. | Combination. | Number of observations. | Number of stars. | Latitude. | Correction to microm. |
|---|---|---|---|---|---|---|---|---|---|
| | | | ° ′ ″ | ″ | | | | ° ′ ″ | ″ |
| 1 | 2 | 3 | 32 47 41.0 | — 1.0 | 17 | 3 | 2 | 32 47 38.6 | + 1.5 |
| 2 | 3 | 4 | 38.2 | + 0.2 | 18 | 4 | 2 | 39.5 | + 0.6 |
| 3 | 4 | 2 | 38.2 | + 1.2 | 19 | 5 | 2 | 41.0 | — 0.1 |
| 4 | 2 | 2 | 43.7 | 0.0 | 20 | 5 | 3 | 39.6 | + 0.3 |
| 5 | 4 | 2 | 40.3 | + 0.2 | 21 | 4 | 2 | 40.0 | — 0.2 |
| 6 | 4 | 2 | 41.6 | + 0.3 | 22 | 5 | 3 | 40.0 | + 0.2 |
| 7 | 2 | 2 | 41.5 | — 1.6 | 23 | 4 | 2 | 38.4 | + 1.3 |
| 8 | 5 | 5 | 40.0 | + 0.5 | 24 | 4 | 3 | 39.8 | + 0.5 |
| 9 | 5 | *4 | 40.5 | + 0.3 | 25 | 5 | 2 | 38.0 | + 1.2 |
| 10 | 4 | 2 | 41.7 | + 0.3 | 26 | 5 | 2 | 39.7 | + 0.8 |
| 11 | 5 | *6 | 40.2 | + 0.1 | 27 | 5 | 2 | 41.4 | — 0.7 |
| 12 | 5 | 2 | 40.6 | + 0.4 | 28 | 2 | 2 | 39.8 | — 0.5 |
| 13 | 5 | 2 | 39.7 | + 1.0 | 29 | 2 | 3 | 41.4 | — 0.6 |
| 14 | 5 | 3 | 39.2 | + 0.2 | 30 | 2 | 4 | 40.8 | 0.0 |
| 15 | 5 | 2 | 40.5 | + 0.5 | 31 | 2 | 2 | 41.1 | — 0.4 |
| 16 | 3 | 2 | 40.1 | — 0.4 | ....... | ....... | ....... | ............... | ......... |

Final latitude: 32° 47′ 40″.35 ± 0″.18.

In this station's work it was found that the levels were uncertain. Hence a correction was applied to each result as given in the table of details to reduce to the constant level values for the several nights:

October 4, + 0″.1.
October 6, — 1″.4.
October 7, — 2″.6.
October 8, — 1″.4.
October 9, — 1″.6.

That is, the two observations of combination 1, October 8 and 9, where level corrections in the tables of details are + 2″.5 and — 1″.8, respectively, receive the corrections — 3″.9 and + 0″.2, reducing to — 1″.4 and — 1″.6. In this way the agreement of the pairs (see above) is much improved; but the probable error of final latitude is calculated allowing for the probable error ± 0″.12, derived from the table just preceding, and ± 0″.14 uncertainty of the mean of levels for five nights.

**The following table comprises the latitudes of a number of points at which sextant observations were made during 1878, and the subsequent computations by officers of the survey, during the office season, viz:**

*Geographical positions from sextant observations, variations of needle, altitudes, &c., for the year* 1878.

| Year. | Station. | State or Territory. | Atlas sheet. | Objects observed. | Latitude. | | | Altitude above sea-level. | Variation of the needle east. | | Observer. | Computer. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ° | ′ | ″ | Feet. | ° | ′ | | | |
| 1878 | Rabbit Creek | Oreg. | 29*d* | α Cygni<br>α Bootis<br>Polaris | 42 | 29 | 00.3 | 5327.4 | ........ | | Lieut. Symons | J. C. Spiller | |
| 1878 | Abert Lake | Oreg. | 29*d* | α Bootis<br>Polaris | 42 | 44 | 49.4 | 4208.7 | 23 | 55 | Lieut. Symons | J. C. Spiller | North end. |
| 1878 | Foster's Ranch, west shore of Summer Lake. | Oreg. | 29*c* | β Pegasi<br>α Bootis<br>Polaris<br>Altair | 42 | 47 | 21.7 | 4174.3 | 18 | 07 | Lieut. Symons | J. C. Spiller | Pass over Rim Rocks. |
| 1878 | Sykan Marsh | Oreg. | 29*c* | β Pegasi<br>α Coronæ Borealis<br>Polaris<br>Altair | 42 | 42 | 43.2 | 4959.9 | ........ | | Lieut. Symons | J. C. Spiller | Southern end. |
| 1878 | Camp 12, spring on Oregon Central Military Road. | Oreg. | 29*c* | β Pegasi<br>α Coronæ Borealis<br>Polaris<br>Altair | 42 | 39 | 18.5 | 5503.7 | 23 | 13 | Lieut. Symons | J. C. Spiller | |
| 1878 | Four-mile Lake | Oreg. | 29*c* | α Andromedæ<br>α Coronæ Borealis<br>Polaris<br>Altair | 42 | 26 | 43.35 | 5610.2 | 18 | 19 | Lieut. Symons | J. C. Spiller | |
| 1878 | Fort Klamath | Oreg. | 29*c* | α Andromedæ<br>α Coronæ Borealis<br>Polaris<br>Altair | 42 | 41 | 03.0 | 4108.4 | 19 | 41 | Lieut. Symons | J. C. Spiller | |
| 1878 | Camp 21, on Williamson's River. | Oreg. | 29*c* | α Andromedæ<br>α Coronæ Borealis<br>Polaris<br>Altair | 42 | 44 | 49.2 | 4298.6 | ........ | | Lieut. Symons | J. C. Spiller | |
| 1878 | Camp 24 | Oreg. | 29*a* | α Coronæ Borealis<br>Polaris<br>Altair | 43 | 21 | 37.8 | 4568.7 | 18 | 56 | Lieut. Symons | J. C. Spiller | On headwater stream of Deschutes River, southeast of Diamond Peak. |
| 1878 | Summit Lake | Oreg. | 28*b* | α Coronæ Borealis<br>Polaris<br>Altair | 43 | 27 | 30.4 | 5010.1 | 19 | 22 | Lieut. Symons | J. C. Spiller | Camp west of. |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1878 | Odell Lake | Oreg | 28*b* | α Andromedæ<br>α Coronæ Borealis<br>Polaris<br>Altair | 43 | 38 | 15.5 | 5483.7 | 18 | 25 | Lieut. Symons | J. C. Spiller | Camp north of. |
| 1878 | Davis Lake | Oreg | 29*a* | α Andromedæ<br>α Coronæ Borealis<br>Polaris<br>Altair | 43 | 38 | 25.4 | 4466.0 | ........ | | Lieut. Symons | J. C. Spiller | Camp north end of. |
| 1878 | Farewell Bend, ford of Deschutes River. | Oreg | 20*c* | α Pegasi<br>α Coronæ Borealis<br>Polaris<br>Altair | 44 | 03 | 47.6 | 3620.9 | 19 | 34 | Lieut. Symons | J. C. Spiller | |
| 1878 | Tygh Valley | Oreg | 20*a* | α Pegasi<br>α Coronæ Borealis<br>Polaris<br>Altair | 45 | 14 | 38.4 | 1088.8 | 17 | 05 | Lieut. Symons | J. C. Spiller | |
| 1878 | Fifteen-mile Creek | Oreg | 20*a* | α Pegasi<br>ζ Hercules<br>Polaris<br>Altair | 45 | 26 | 58.5 | 1266.7 | 19 | 29 | Lieut. Symons | J. C. Spiller | Dufur's Ranch. |
| 1878 | Langton's Ranch | Oreg | 29*a* | γ Pegasi<br>α Lyræ<br>Polaris<br>ε Pegasi | 43 | 35 | 00.8 | 5162.7 | 18 | 45 | Lieut. Symons | J. C. Spiller | Water holes; Great Oregon Desert. |
| 1878 | Silver Lake | Oreg | 29*c* | α Lyræ<br>Polaris | 43 | 06 | 54.8 | ........ | ........ | | Lieut. Symons | J. C. Spiller | Durand's Ranch. |
| 1878 | Chewaucan Valley, south and upper valley. | Oreg | 29*d* | γ Pegasi<br>Altair<br>Polaris<br>ε Pegasi | 42 | 32 | 05.0 | 4336.0 | 18 | 27 | Lieut. Symons | J. C. Spiller | Moss' Ranch. |
| 1878 | Cress' Ranch, near | Cal | 47*a* | Arcturus<br>α Cygni<br>α Ophiuchi<br>Polaris<br>Sun | 39 | 52 | 00.1 | 5157.0 | 17 | 38 | Lieut. Tillman | Lieut. Griffin | Camp 9. |
| 1878 | Quincy, near | Cal | 47*a* | Arcturus<br>α Cygni<br>Polaris<br>Sun | 39 | 56 | 04.2 | 3381.0 | 17 | 20 | Lieut. Tillman | Lieut. Griffin | Camp 10. |
| 1878 | Taylorsville, near | Cal | 47*a* | Arcturus<br>α Cygni<br>Polaris<br>Sun | 40 | 04 | 59.4 | 3479.0 | 17 | 19 | Lieut. Tillman | Lieut. Griffin | Camp 12. |
| 1878 | Camp 13 | Cal | 47*a* | α Cygni<br>Arcturus<br>Polaris | 39 | 56 | 43.8 | 5607.3 | 17 | 03 | Lieut. Tillman | Lieut. Griffin | Head of Grizzly Valley. |
| 1878 | Camp 27 | Cal | 47*a* | α Coronæ Borealis<br>α Aquilæ<br>Polaris | 40 | 07 | 36.7 | 4989.7 | 18 | 40 | Lieut. Tillman | Lieut. Griffin | Colby's Ranch. |

*Geographical positions from sextant observations, variations of needle, altitudes, &c.*—Continued.

| Year. | Station. | State or Territory. | Atlas sheet. | Objects observed. | Latitude. | | | Altitude above sea-level. | Variation of the needle east. | | Observer. | Computer. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | ° | ′ | ″ | Feet. | ° | ′ | | | |
| 1878 | Deer Creek Meadow | Cal | 47*a* | Sun<br>α Coronæ Borealis<br>Polaris | 40 | 16 | 14.9 | 4518.1 | 16 | 40 | Lieut. Tillman | Lieut. Griffin | On Lost Creek, one mile above junction with Deer Creek. |
| 1878 | Johnson's Ranch, near Susanville. | Cal | 47*a* | α Aquilæ<br>Polaris<br>ε Pegasi<br>α Andromedæ | 40 | 21 | 44.6 | 4378.8 | 18 | 50 | Lieut. Tillman | Lieut. Griffin | Variation given for Susanville. |
| 1878 | Camp 32 | Cal | 47*a* | α Lyræ<br>α Coronæ Borealis<br>Polaris | 40 | 26 | 14.5 | 5816.0 | 18 | 41 | Lieut. Tillman | Lieut. Griffin | Upper ranch on Warner Creek. |
| 1878 | Pine Creek | Cal | 47*a* | α Aquilæ<br>α Andromedæ<br>α Lyræ<br>Polaris | 40 | 35 | 00.2 | 5409.1 | 18 | 45 | Lieut. Tillman | Lieut. Griffin | At ranch at upper end of flat. |
| 1878 | Camp 51 | Cal | 47*a* | ε Pegasi<br>ε Pegasi<br>Polaris | 40 | 37 | 49.9 | 5303.2 | 16 | 26 | Lieut. Tillman | Lieut. Griffin | Six miles north of Cinder Cone. |
| 1878 | Ogburn's Ranch | Cal | 47*a* | α Lyræ<br>ε Pegasi<br>Polaris | 40 | 30 | 15.4 | 2269.5 | 16 | 45 | Lieut. Tillman | Lieut. Griffin | |
| 1878 | West Point | Cal | 56*b* | α Lyræ<br>α Ophiuchi<br>Altair<br>Polaris | 38 | 23 | 56.9 | 2773.7 | 16 | 47 | Lieut. Macomb | Lieut. Griffin | |
| 1878 | Antelope | Cal | 56*b* | η Ursæ majoris<br>α Ophiuchi<br>Altair<br>α Coronæ Borealis | 38 | 30 | 31.0 | 4272.5 | 16 | 49 | Lieut. Macomb | Lieut. Griffin | |
| 1878 | Half-way House | Cal | 56*b* | Polaris<br>α Coronæ Borealis<br>Polaris<br>Markab | 38 | 11 | 57.8 | 3358.5 | 16 | 33 | Lieut. Macomb | Lieut. Griffin | |
| 1878 | Gold Spring Ranch | Cal | 56*b* | Altair<br>α Coronæ Borealis<br>Altair<br>Markab<br>Polaris | 38 | 02 | 45.3 | 1938.5 | 16 | 47 | Lieut. Macomb | Lieut. Griffin | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1878 | Strawberry, Sonora Road. | Cal ..... | 56b | Markab..................<br>α Ophiuchi ................<br>Polaris.................. | 38 | 11 | 36.3 | 5237.8 | ........ | | Lieut. Macomb.. | Lieut. Griffin... | |
| 1878 | Hetch-Hetchy Valley..... | Cal | 56b | ε Pegasi ..................<br>Polaris..................<br>α Persei .................. | 37 | 57 | 17 | 3437.3 | ........ | | Lieut. Macomb.. | Lieut. Griffin... | |
| 1878 | Ojo San Nicholas ........ | N. Mex. | 84d | Sun ..................<br>Polaris ..................<br>Altair .................. | 32 | 35 | 25.5 | 4218.0 | 11 | 29 | Lieut. Griffin.... | Lieut. Griffin.... | |
| 1878 | Silver Spring, Sacramento Mountains. | N. Mex. | 84d | Polaris.................. | 33 | 01 | 48.9 | 7638.2 | 13 | 11 | Lieut. Griffin.... | Lieut. Griffin.... | |
| 1878 | Peñasco Creek............ | N. Mex. | 84d | Sun ..................<br>Polaris.................. | 32 | 49 | 14.5 | 6486.6 | 12 | 55 | Lieut. Griffin.... | Lieut. Griffin.... | |
| 1878 | Fort Klamath............ | Oreg. | 29c | Altair ..................<br>α Coronæ Borealis ..........<br>Polaris.................. | 42 | 41 | 07.7 | 4108.4 | 19 | 41 | Lieut. Symons .. | M. Rock........ | |
| 1873 | Fort Grant .............. | Ariz. | 83c | α Arietis..................<br>Altair ..................<br>α Coronæ Borealis ..........<br>γ Pegasi ..................<br>Polaris.................. | 32 | 36 | 56.7 | 4833.1 | 13 | 49 | Lieut. Russell... | M. Rock........ | Mean of two nights |

The executive report of Professor Safford, who occupied the observatory at Ogden, Utah, appears as Appendix H.

Assistant John H. Clark presents a brief account of his occupancy of three of the five main stations. (See Appendix I.)

While *en route* to his field of duty in Southern New Mexico, Assistant Miles Rock found himself at Santa Fé, N. Mex., within the line of shadow of the total solar eclipse of July 27, 1878; his observations are noted in his brief report. (See Appendix J.)

It had been intended to make brief mention of the use of the observatory by the French commission of astronomers sent to observe the transit of Mercury of May 6, 1878, in the report of that year. The party consisted of Prof. Charles André, director of the Observatory of Lyons; Alfred Angôt, professor of physics in the Lycée Fontanes, Paris, and Monsieur Hatt, hydrographic engineer of the French navy. The observatory and its appurtenances were placed at the disposal of these gentlemen, and such assistance as was practicable was rendered by Assistant Francis Klett and Sergeant Hoffmann, Fourteenth Infantry. The commission were present in Ogden from April 2 to May 11, and while the observations were not wholly successful, a considerable number of photographs of the different phases of the transit were secured. The official report showing the results of these observations is awaited with much interest.

## GEODETIC AND TOPOGRAPHICAL.

Five bases have been measured in the vicinity of the following points: 1, Austin, Nev.; 2, Fresno, Cal.; 3, Dalles, Oreg.; 4, Fort Bliss, Texas; 5, Fort Bayard, N. Mex., and the development made therefrom in each instance.

### AUSTIN AUXILIARY BASE.

This line was located about 1 mile northeast by east from Austin, and was measured for the purpose of connecting the astronomical monument at Austin with Mount Prometheus. The line was measured but once, by Lieutenant Ludlow and Mr. Klett. The measurement was made on stakes driven into the ground and aligned for the purpose; the difference of level for each fifty feet was obtained by using the same stakes as stations. The measured length of the line was 500 feet.

### FRESNO BASE.

This line was located about 5 miles east of Fresno. It was twice measured with a compensated steel-tape line (Stackpole make); the tape was daily twice compared with standard rods. The measurement was made on stools 3 feet above the ground. These stools were centered by plumb-lines over a wire 600 feet long, which was tightly stretched in the direction of the base line. The two measurements were made by Lieutenant Ludlow, Mr. Klett, and Mr. Bailey, and differed by 0.3 inch, the mean length being 22,227.04 feet. The line was leveled by Mr. Klett, the distance between the level stations depending upon the nature of the ground.

### DALLES BASE.

The base line at the Dalles was selected by Lieutenant Symons, and was located northwest of the town. It was twice measured with a Stackpole compensated steel tape, the two measures differing by 0.3 feet. The first measurement was made by Lieutenant Symons and Mr. Kahler; the second was made by Mr. Kahler. The line was leveled by Mr.

Kahler, the triangulation instrument being used for the purpose. Stakes were driven every 50 feet and measures made upon these as were also the levels. The measurement reduced for level and elevation above the sea gives for the adopted length of the base, at sea-level, 8,639.974 feet. The ends of the base were marked by iron pins driven into the ground. For the purpose of development large wooden frames were erected over the ends of the line, but were not intended to be permanent.

### FORT BLISS BASE.

This line was laid out on a nearly level plain about 5 miles east of Franklin, Tex. The ends were marked by cross-lines on copper tacks driven into large wooden pegs which were firmly set in the ground. The line between the ends was carefully grubbed of the small bushes, and was made as smooth as possible. It was also leveled and a correction determined to the measured distance. The measurements, two in number, were made with a compensated 50-feet steel tape by Stackpole, which was set at 90°, the difference between the actual and set temperatures at each 1,000 feet being noted and the corresponding corrections computed. The ends of each 50 feet were marked by pins stuck in board boxes which were firmly fixed by means of long iron nails which were pressed into the earth. The results were as follows:

| | Feet. | Temp. cor. feet. | Level cor. feet. | Feet. |
|---|---|---|---|---|
| First measurement by Maxson & Walbridge .. | 8,049.689 | + 0.632 | – 0.020 | = 8,050.291 |
| Second measurement by Griffin & Maxson.... | 8,049.789 | + 0.512 | – 0.020 | = 8,050.271 |
| Mean .......... | | | | 8,050.281 |
| Reduction to sea-level.......... | | | | 1.321 |
| Length of base at sea-level .......... | | | | 8,048.960 |

### BAYARD BASE.

Was measured on the plain west of the Santa Rita Mountains, near the warm springs of Apache Tejo. The line was twice measured by Mr. Nell and his assistant Mr. Gillette, and leveled by the latter. The measurement was made with a Stackpole compensated steel-tape line of 50 feet length.

The first measurement gave 27,265.968 feet.
The second measurement gave 27,265.906 feet.

The separate lengths of the line were marked by pins on boards placed at the proper distances for the purpose. The temperature of the tape was recorded every 1,000 feet and adjusted at the same intervals. The ends of the line were marked by wooden poles 6 inches in diameter. These marks were not intended to be permanent.

A triangulation has been extended over the area occupied by each party connecting with that of previous years, except the larger area traversed by the two divisions of party 1, California section, about 18,000 square miles, that in one season could only be fairly reconnoitered for the best selection of points. More than ordinary care has been observed in selecting the best points and in multiplying observations.

The area covered topographically has been approximately 26,559 square miles, and is distributed in the following basins of drainage:

The northwestern arm of the "Great Interior Basin." The basin of the Upper Klamath River, and the basin of the Columbia contiguous to and east of the Cascade Range. In the mountain basins at the head waters of the Tuolumne, Stanislaus, Merced, and Feather Rivers, all of which are tributary to the inland valleys of California. A portion of the area also fell in the basin of the Rio Grande.

The elevations above sea at which the work has been carried on vary from 171 feet as the lowest to 14,000 feet, being White Mountain Peak, Nevada, as the highest. Land classification data have been secured incidentally to the progress of the work. Magnetic observations have been secured at all prominent points. As usual, connection has been made with boundary monuments and stakes of the United States land survey where the latter were found. The special survey of the Great Salt Lake and vicinity has been completed so far as relates to its meander and that of the islands, and their contour with numerous soundings and observations for surface evaporation have been made. In order to complete the triangulation and topography of certain atlas sheets already entered upon, viz, 20 A, 20 C, 29 A, 29 C, 38 B, 56 D, 73, 52 D, 80 B, 84 D, 90 A, and 90 C, it will be necessary that a number of small parties shall take the field during a subsequent season to fill gaps. (See statement at end of office estimate.)

The route followed by myself during the season of 1878 was from Reno, on the Central Pacific Railroad, to Camp Bidwell, Cal.; thence to Fort Klamath, Oreg.; thence northward to the Dalles, on the Columbia River, and eastward to Walla Walla, in Washington Territory.

This gave me an opportunity to see the northwestern arm of the great interior basin and its approach to the Cascade Range, the relation between the northern Sierras and the former range, and to scan large interior areas east of the Cascades, to note the extremely desert-like appearance of Northwestern Nevada, and to encompass as well within one season's observations a transit of the luxurious valley of the Willamette; and thus desert, valley, mountain, and plain were cursorily examined, and an opportunity afforded to contrast this section with that of like altitudes visited in other field seasons at lower latitudes, and to select elevated geodetic stations to the eastward of the Cascades, to be occupied in the development of a network of triangles, extending from the Central Pacific Railroad to the Columbia River, and covering large parts of California, Nevada, and Oregon.

Other than this brief mention will be left to volume 1, soon forthcoming, that treats somewhat systematically the area visited by myself during the several expeditions.

The lines of the earlier explorers—Frémont, Williamson, and Abbott—along the east base of the Cascades were followed in part, and scenes made familiar by their writings recognized. This section is still an almost untrodden wilderness, unbroken save now and then by the presence of an adventurous ranchman and stock-raiser, changing, however, as one nears the Columbia River, where, at intervals of never less than 5 miles, a few small farming settlements appear.

*Geographical positions of military posts.*

| No. | Name of post. | Latitude. | | | Longitude. | | | Altitude above sea level. | Magnetic declination, with date of determination. | | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ° | ′ | ″ | ° | ′ | ″ | Feet. | ° | ′ | ″ | | |
| 1 | Apache, Fort, Arizona | 33 | 47 | 18.70 | 109 | 57 | (†) | 5,000.9 | 14 | 10 | 42 | 1871 | Latitude by sextant. |
| 2 | Bayard, Fort, New Mexico (astronomical monument) | 32 | 47 | 41. | 108 | 09 | 08. | 6,098.0 | 12 | 56 | 00 | 1878 | Not final. Longitude by telegraph and transit. Latitude by zenith telescope. |
| 3 | Bidwell, Fort, California (flagstaff) | 41 | 51 | 30.94 | 120 | 09 | 15.56 | 4,647.0 | 17 | 53 | 00 | 1877 | Trigonometrical connection with triangulation. |
| 4 | Bliss, Fort, Texas (astronomical monument) | 31 | 45 | 31. | 106 | 29 | 05. | 3,623. | 12 | 25 | 15 | 1878 | Not final. Longitude by telegraph and transit. Latitude by zenith telescope. |
| 5 | Bowie, Fort, Arizona | 32 | 10 | 16.2 | (not reduced.) | | | 4,871.6 | 13 | 47 | 53 | 1873 | Latitude by sextant. |
| 6 | Cameron, Fort, Utah (the first building erected, 1872) | 38 | 16 | 53.34 | 111 | 44 | 00.31 | 6,057.7 | 16 | 24 | 00 | 1873 | Trigonometrical connection with triangulation. |
| 7 | Cheyenne Depot, Wyoming | 41 | 07 | 57.77 | 104 | 49 | 11.65 | 6,041.0 | | | | | Trigonometrical connection with Cheyenne astronomical monument. Altitude of astronomical monument. |
| 8 | Craig, Fort, New Mexico (flagstaff) | 33 | 38 | 00.99 | 107 | 01 | 7.96 | 4,447.5 | 12 | 59 | 09 | 1873 | Trigonometrical connection with triangulation. |
| 9 | Douglass, Fort, Utah (astronomical monument) | 40 | 45 | 47.58 | 111 | 50 | 14.07 | 4,905. | 17 | 01 | 00 | 1872 | By traverse line to Coast Survey station at Salt Lake City. |
| 10 | Ellis, Fort, Montana (flagstaff) | 45 | 40 | 13.45 | 110 | 58 | 30.97 | | 19 | 13 | 00 | 1877 | Trigonometric connection with astronomical monument at Bozeman. Magnetic declination for Bozeman. |
| 11 | Fred Steele, Fort, Wyoming (flagstaff) | 41 | 46 | 50.63 | 106 | 56 | 54.27 | 6,850.0* | 16 | 27 | 10 | 1873 | Trigonometric connection with astronomical monument. |
| 12 | Garland, Fort, Colorado (flagstaff) | 37 | 25 | 27.33 | 105 | 25 | 33.73 | 7,937.0* | 14 | 07 | 08 | 1873 | Trigonometric connection with triangulation. |
| 13 | Grant, Fort, Arizona | 32 | 36 | 56.7 | | | | 4,833.1 | 13 | 49 | 00 | 1873 | Latitude by sextant. |
| 14 | Hall, Fort, Idaho (flagstaff) | 43 | 08 | 54.8 | | | | 4,752.1 | 18 | 13 | 00 | 1877 | Latitude by sextant. |
| 15 | Halleck, Fort, Nevada | 40 | 48 | 34.35 | 115 | 19 | 34.05 | 5,789.7 | 16 | 21 | 24 | 1869 | Longitude by telegraph and sextant. Latitude by sextant. |
| 16 | Klamath, Fort, Oregon | 42 | 41 | 07.7 | | | | 4,108.4 | 19 | 41 | 00 | 1878 | Latitude by sextant. |
| 17 | Marcy, Fort, Santa Fé, N. Mex. (astronomical monument). | 35 | 41 | 19.29 | 105 | 56 | 45.22 | 6,965.2 | 13 | 09 | 32 | 1874 | Longitude by telegraph and transit. Latitude by zenith telescope. |
| 18 | Mohave, Fort, Arizona | 35 | 02 | 09. | 114 | 35 | 54. | 755.8 | 14 | 45 | 00 | 1875 | By connection with iron monument of the California boundary. |
| 19 | North Platte Station, Nebraska (astronomical monument). | 41 | 08 | 18.33 | 100 | 45 | 53.14 | 2,789.0 | | | | | Longitude by telegraph and transit. Latitude by zenith telescope. |
| 20 | Russell, Fort D. A., Wyoming (flagstaff) | 41 | 08 | 38.83 | 104 | 50 | 24.47 | 6,041.0 | | | | | Trigonometrical connection with Cheyenne astronomical monument. Altitude of the astronomical monument. |
| 21 | Sanders, Fort, Wyoming (flagstaff) | 41 | 17 | 26.89 | 105 | 34 | 59.56 | 7,168.0* | 15 | 30 | 00 | 1873 | Connection by traverse line with the astronomical monument at Laramie City. |
| 22 | Sidney, Fort, Nebraska (astronomical monument) | 41 | 08 | 36.75 | 102 | 58 | 13.32 | 4,106.3 | | | | | Longitude by telegraph and transit. Latitude by zenith telescope. |
| 23 | Stanton, Fort, New Mexico (flagstaff) | 33 | 29 | 35.72 | 105 | 31 | 59.72 | 6,151.5 | 12 | 24 | 00 | 1878 | Trigometrical connection with triangulation. |
| 24 | Union, Fort, New Mexico (astronomical monument) | 35 | 54 | 24.86 | 105 | 00 | 51.15 | 6,744.1 | 14 | 40 | 00 | 1874 | Longitude by telegraph and transit. Latitude by zenith telescope. |

* The altitudes marked with an asterisk are from railroad levels, all others from barometric determinations. † Approximate.

*Geographical positions of military posts*—Continued.

| No. | Name of posts. | Latitude. | | | Longitude. | | | Altitude above sea level. | Magnetic declination, with date of determination. | | | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | ° | ′ | ″ | ° | ′ | ″ | *Feet.* | ° | ′ | ″ | | |
| 25 | Verde, Fort, Arizona | 34 | 34 | 20.19 | 111 | 53 | (*) | 3,159.7 | | | | | Latitude by sextant. |
| 26 | Whipple Barracks, Arizona | 34 | 33 | 06.12 | 112 | 27 | 10.20 | 5,318.0 | | | | | Longitude by lunar culminations. Latitude by zenith telescope. |
| 27 | Wingate, Fort, New Mexico (flagstaff) | 35 | 28 | 49.47 | 108 | 32 | 20. (*) | 6,982.1 | 14 | 51 | 27 | 1873 | Latitude by sextant. |

* Approximate.

*List of Triangulation Stations.*

| Number. | Name of peak. | State or Territory. | Atlas sheet. | Latitude. | Longitude. | Altitude. | Remarks. |
|---|---|---|---|---|---|---|---|
| | | | | ° ′ ″ | ° ′ ″ | | |
| | Primary triangulation stations: | .......... | 56 | .......... | .......... | .......... | Triangulation sheet No. 8. |
| 1 | Pyramid | California | 56*b* | 38 50 34 | 120 9 19 | 10,127.1 | |
| 2 | Freel's | do | 56*b* | 38 51 19 | 119 53 50 | 10,848.9 | |
| 3 | Silver Lake | Nevada | 56*b* | 38 51 45 | 119 28 34 | .......... | |
| 4 | Elephant | California | 56*b* | 38 39 40 | 119 59 54 | 10,418.9 | |
| 5 | Mokelumne | do | 56*b* | 38 32 9 | 120 5 30 | 9,467.2 | |
| 6 | Highland | do | 56*b* | 38 32 28 | 119 45 10 | 10,955.6 | |
| 7 | Sweetwater | do | 56*b* | 38 26 3 | 119 18 7 | 11,778.1 | |
| 8 | Sonora | do | 56*b* | 38 21 4 | 119 37 57 | 11,478.7 | |
| 9 | Conness | do | 56*d* | 37 57 51 | 119 19 6 | 12,518.4 | |
| 10 | Hoffmann | do | 56*d* | 37 50 39 | 119 30 28 | 10,871.7 | |
| 11 | Moccasin | do | 56*d* | 37 48 8 | 120 19 34 | 2,971.3 | |
| 12 | Clark | do | 56*d* | 37 41 36 | 119 25 33 | 11,266.0 | |
| 13 | Devil's | do | 56*d* | 37 31 34 | 119 44 17 | 6,909.9 | |
| 14 | Schultz | do | 56*d* | 37 26 33 | 120 8 33 | 2,275.2 | |
| 15 | Chiquito | do | 56*d* | 37 20 47 | 119 25 32 | 8,136.2 | |
| 16 | Lyell | do | 56*d* | 37 44 11 | 119 16 7 | 13,190.7 | |
| | Secondary triangulation stations: | .......... | 56 | .......... | .......... | .......... | Do. |
| 17 | Stevens' | California | 56*b* | 38 43 53 | 119 58 44 | 10,011.3 | |
| 18 | Cary's | do | 56*b* | 38 44 10 | 119 52 11 | 9,970.2 | |
| 19 | Dunderberg | do | 56*d* | 38 3 43 | 119 16 17 | 12,289.2 | |
| 20 | Wade's | do | 56*d* | 37 51 9 | 119 47 17 | 7,153.5 | |
| 21 | Engineer | do | 56*d* | 37 49 55 | 119 23 35 | 11,231.4 | |
| 22 | Cloud Rest | do | 56*d* | 37 45 53 | 119 29 12 | 9,772.5 | |
| 23 | Merced | do | 56*d* | 37 37 55 | 119 23 31 | 11,413.3 | |
| 24 | Pilot | do | 56*d* | 37 45 36 | 119 56 1 | .......... | |
| | Primary triangulation stations: | .......... | 57 | .......... | .......... | .......... | Do. |
| 25 | Basalt | Nevada | 57*a* | 38 59 10 | 118 25 59 | 6,599.2 | |
| 26 | Paradise | do | 57*b* | 38 48 16 | 117 49 23 | 8,662.4 | |
| 27 | Poston | do | 57*b* | 38 49 49 | 117 20 56 | 11,977.7 | |
| 28 | Cory | do | 57*a* | 38 33 57 | 118 47 16 | 11,326.0 | |
| 29 | Dana | California | 57*c* | 37 53 49 | 119 13 5 | .......... | |
| 30 | McBride | do | 57*c* | 37 50 8 | 118 21 13 | 13,442.7 | |
| 31 | White Mountain | do | 57*c* | 37 37 51 | 118 15 8 | .......... | |
| 32 | Morgan | do | 57*c* | 37 24 7 | 118 43 47 | .......... | |
| | Primary triangulation stations: | .......... | 64 | .......... | .......... | .......... | Do. |
| 33 | Green Mountain | California | 64*b* | 37 15 44 | 119 59 20 | 1,351.7 | |
| 34 | Deadwood | do | 64*b* | 37 18 37 | 119 41 00 | 4,451.3 | |
| | Primary triangulation stations: | .......... | 65 | .......... | .......... | .......... | Do. |
| 35 | Waucoba | California | 65*a* | 37 1 8 | 118 0 23 | 11,267.1 | |
| 36 | New York Butte | do | 65*a* | 36 38 41 | 117 55 56 | .......... | |
| 37 | Whitney | do | 65*a* | 36 34 33 | 118 17 32 | 14,448.4 | |
| 38 | Olancha | do | 65*c* | 36 15 44 | 118 7 10 | 12,250.8 | |
| 39 | Maturango | do | 65*d* | 36 6 56 | 117 29 50 | *8,844 | |
| 40 | Sunday | do | 65*c* | 35 46 48 | 118 35 17 | 8,334.8 | |
| 41 | Owen's | do | 65*c* | 35 44 5 | 118 0 0 | .......... | |
| 42 | Telescope | do | 65*d* | 36 9 52 | 117 5 27 | *10,937 | |
| 43 | Wahguyhe | do | 65*b* | 36 56 4 | 117 6 16 | *8,527.9 | |
| | Secondary triangulation stations: | .......... | 65 | .......... | .......... | .......... | Do. |
| 44 | Corcoran | California | 65*a* | 36 31 14 | 118 14 24 | 14,093.7 | |
| 45 | Thunder | do | 65*c* | 36 4 52 | 118 34 41 | 9,121.7 | |
| | Primary triangulation stations: | .......... | 32 | .......... | .......... | .......... | Triangulation sheet No. 11. |
| 46 | Big Butte | Idaho | 32*a* | 43 23 42 | 113 1 38 | 7,658.7 | |
| 47 | Mount Pisgah | do | 32*d* | 43 5 34 | 111 18 58 | 9,694.6 | |
| 48 | Mount Putnam | do | 32*d* | 42 57 8 | 112 10 10 | 8,905.3 | |
| 49 | Meade | do | 32*d* | 42 29 41 | 111 15 11 | 10,540.9 | |
| 50 | Elkhorn (north point). | do | 32*d* | 42 20 0 | 112 19 56 | .......... | |
| | Secondary triangulation stations: | .......... | 32 | .......... | .......... | .......... | Do. |
| 51 | Pillar Butte | Idaho | 32*c* | 42 52 58 | 113 13 9 | 5,301.1 | |
| 52 | Badger | do | 32*c* | 42 33 1 | 113 4 1 | 6,389.0 | |
| 53 | Bannock | do | 32*c* | 42 36 9 | 112 42 43 | 8,358.9 | |
| 54 | South Putnam | do | 32*d* | 42 55 3 | 112 7 58 | .......... | |
| 55 | Cedar Creek | do | 32*c* | 42 26 46 | 113 3 35 | 7,586.5 | |
| 56 | Deep Creek | do | 32*c* | 42 28 13 | 112 39 38 | 8,817.6 | |
| 57 | Sedgwick | do | 32*d* | 42 30 54 | 111 55 40 | 9,207.2 | |

*List of Triangulation Stations*—Continued.

| Number. | Name of peak. | State or Territory. | Atlas sheet. | Latitude. | | | Longitude. | | | Altitude. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | ° | ′ | ″ | ° | ′ | ″ | | |
| 58 | Sherman | Idaho | 32*d* | 42 | 27 | 52 | 111 | 33 | 11 | 9,572.0 | Triangulation sheet No. 11. |
| | Primary triangulation stations: | | 40 | | | | | | | | Triangulation sheet No. 12. |
| 59 | Pilot Knob | Nevada | 40*d* | 41 | 1 | 12 | 114 | 4 | 52 | 10,758.3 | |
| 60 | Desert | Utah | 40*d* | 40 | 57 | 2 | 113 | 47 | 36 | 8,175.4 | |
| | Primary triangulation stations: | | 41 | | | | | | | | Do. |
| 61 | Cache | Idaho | 41*a* | 42 | 11 | 4 | 113 | 39 | 55 | 10,451.2 | |
| 62 | Black Pine | do | 41*a* | 42 | 7 | 8 | 113 | 7 | 28 | 9,386.0 | |
| 63 | Clear Creek | Utah | 41*a* | 41 | 41 | 23 | 113 | 44 | 44 | 9,132.1 | |
| 64 | Blue Spring | do | 41*a* | 41 | 47 | 36 | 112 | 32 | 54 | 7,131.4 | |
| 65 | Naomi | do | 41*b* | 41 | 54 | 39 | 111 | 40 | 46 | 9,951.0 | |
| 66 | Tangent | do | 41*c* | 41 | 28 | 51 | 113 | 10 | 42 | | |
| 67 | Promontory | do | 41*c* | 41 | 29 | 22 | 112 | 30 | 45 | 7,459.7 | |
| 68 | Newfoundland | do | 41*c* | 41 | 11 | 7 | 113 | 22 | 19 | 7,045.5 | |
| 69 | North Ogden | do | 41*d* | 41 | 21 | 45 | 111 | 57 | 53 | 9,695.7 | |
| 70 | Observatory | do | 41*d* | 41 | 11 | 57 | 111 | 53 | 10 | 9,589.2 | |
| 71 | Antelope Island | do | 41*d* | 40 | 57 | 40 | 112 | 13 | 12 | 6,660.1 | |
| | Secondary triangulation stations: | | 41 | | | | | | | | Do. |
| 72 | Oxford | Idaho | 41*b* | 42 | 16 | 8 | 112 | 6 | 5 | 9,386.0 | |
| 73 | Castle Rock | do | 41*b* | 42 | 12 | 9 | 111 | 33 | 8 | 9,610.9 | |
| 74 | Kimball's | Utah | 41*b* | 41 | 57 | 40 | 111 | 13 | 57 | 7,777.7 | |
| 75 | Black Butte | do | 41*b* | 41 | 55 | 36 | 112 | 7 | 37 | | |
| 76 | Box Elder | do | 41*b* | 41 | 38 | 6 | 112 | 1 | 7 | 9,541.8 | |
| 77 | South Promontory | do | 41*c* | 41 | 18 | 22 | 112 | 27 | 5 | | |
| 78 | Barton | do | 41*d* | 41 | 4 | 52 | 111 | 51 | 20 | 9,854.2 | |
| 79 | Porcupine | do | 41*d* | 41 | 1 | 7 | 111 | 7 | 7 | | |
| | Primary triangulation station: | | 50 | | | | | | | | Do. |
| 80 | West Twin | Utah | 50*b* | 40 | 35 | 44 | 111 | 43 | 42 | | |
| | Primary triangulation stations: | | 38 | | | | | | | | Triangulation sheet No. 7. |
| 81 | Lo-lo-che-wis | Oregon | 38*a* | 42 | 18 | 22 | 120 | 37 | 38 | 7,957.2 | |
| 82 | Sugarloaf | do | 38*b* | 42 | 17 | 58 | 120 | 7 | 12 | 8,415.6 | |
| 83 | Cedar | California | 38*b* | 41 | 36 | 32 | 120 | 16 | 0 | 8,308.1 | |
| 84 | Warren | do | 38*d* | 41 | 22 | 39 | 120 | 12 | 59 | 9,668.0 | |
| 85 | South Fork | do | 38*d* | 41 | 9 | 14 | 120 | 33 | 39 | 7,408.6 | |
| 86 | Division | Nevada | 38*d* | 41 | 5 | 46 | 119 | 15 | 32 | 8,584.7 | |
| 87 | Mahogany | do | 38*d* | 41 | 1 | 26 | 119 | 33 | 18 | 8,363.1 | |
| 88 | Granite | do | 38*d* | 40 | 47 | 22 | 119 | 25 | 48 | 8,990.1 | |
| 89 | Observation | California | 38*d* | 40 | 46 | 22 | 120 | 10 | 7 | 8,009.3 | |
| 90 | Fredonyer | do | 38*d* | 40 | 41 | 11 | 120 | 35 | 44 | 7,995.2 | |
| | Secondary triangulation stations: | | 38 | | | | | | | | Do. |
| 91 | North End | Oregon | 38*b* | 42 | 3 | 54 | 120 | 14 | 13 | 8,471.6 | |
| 92 | Bidwell | California | 38*b* | 41 | 56 | 52 | 120 | 7 | 50 | 8,551.2 | |
| 93 | Camp Bidwell Flagstaff. | do | 38*b* | 41 | 51 | 31 | 120 | 9 | 16 | 4,647.0 | |
| 94 | Yellow Mesa | Nevada | 38*b* | 41 | 50 | 5 | 119 | 37 | 16 | | |
| 95 | "49" | do | 38*b* | 41 | 33 | 24 | 119 | 55 | 23 | 7,498.0 | |
| 96 | Alturas Hill | California | 38*d* | 41 | 28 | 57 | 120 | 32 | 43 | 4,459.5 | |
| 97 | Eagle | do | 38*d* | 41 | 16 | 56 | 120 | 11 | 51 | 9,933.6 | |
| 98 | Hat | do | 38*d* | 41 | 3 | 57 | 120 | 5 | 48 | 7,676.1 | |
| 99 | McDonald | do | 38*d* | 40 | 56 | 23 | 120 | 24 | 36 | 7,954.0 | |
| | Primary triangulation station: | | 39 | | | | | | | | Do. |
| 100 | Piute | Nevada | 39*c* | 41 | 16 | 43 | 119 | 3 | 23 | 8,618.2 | |
| | Primary triangulation stations: | | 47 | | | | | | | | Do. |
| 101 | Lassen's Butte | California | 47*a* | 40 | 29 | 12 | 121 | 30 | 10 | 10,437.0 | |
| 102 | Hot Springs | do | 47*b* | 40 | 22 | 25 | 120 | 7 | 7 | 7,692.1 | |
| 103 | Thompson | do | 47*b* | 40 | 15 | 34 | 120 | 33 | 17 | 7,752.2 | |
| 104 | To-ha-kum | Nevada | 47*b* | 40 | 10 | 40 | 119 | 27 | 7 | 8,174.0 | |
| 105 | Ingalls' | California | 47*b* | 39 | 59 | 33 | 120 | 37 | 29 | 8,471.5 | |
| 106 | Summit | do | 47*d* | 39 | 42 | 4 | 120 | 8 | 25 | 8,310.9 | |
| 107 | Downieville Butte | do | 47*c* | 39 | 35 | 30 | 120 | 38 | 39 | 8,541.1 | |
| 108 | Peavine | Nevada | 47*d* | 39 | 35 | 7 | 119 | 55 | 44 | 8,281.0 | |
| 109 | Castle | California | 47*d* | 39 | 21 | 48 | 120 | 20 | 47 | 9,013.6 | |
| 110 | Rose | Nevada | 47*d* | 39 | 20 | 30 | 119 | 54 | 54 | 10,820.3 | |
| 111 | Twin | California | 47*d* | 39 | 6 | 37 | 120 | 13 | 47 | 8,823.9 | |
| | Primary triangulation stations: | | 73 | | | | | | | | Triangulation sheet No. 9. |
| 112 | McGill | California | 73*c* | 34 | 48 | 44 | 119 | 8 | 52 | *9,214 | |
| 113 | Tebachapai | do | 73*a* | 35 | 2 | 21 | 118 | 34 | 35 | *8,056 | |

*List of Triangulation Stations*—Continued.

| Number. | Name of peak. | State or Territory. | Atlas sheet. | Latitude. | Longitude. | Altitude. | Remarks. |
|---|---|---|---|---|---|---|---|
| | | | | ° ′ ″ | ° ′ ″ | | |
| 114 | San Fernando ...... | California .. | 73c | 34 19 39 | 118 36 2 | 3,792.8 | Triangulation sheet No. 9. |
| 115 | Saddle, (Malaga) ... | ....do ....... | 73c | 34 4 33 | 118 39 17 | 2,896.6 | |
| 116 | Sister Else, (Station | L).do ...... | 73c | 34 16 50 | 118 14 20 | ......... | |
| 117 | San Gabriel ........ | ....do ....... | 73c | 34 14 27 | 113 5 54 | 6,232.0 | |
| 118 | San Antonio........ | ....do ....... | 73d | 34 17 6 | 117 39 14 | 10,191.9 | |
| 119 | Grizzly ............ | ....do ....... | 73d | 34 5 53 | 116 50 55 | 11,723.4 | |
| 120 | Pilot Knob ......... | ....do ....... | 73b | 35 23 32 | 117 13 50 | 5,525.1 | |
| | Secondary triangulation stations: | ............... | 73 | ......... | ......... | ......... | Do. |
| 121 | Camp Weldon...... | California... | 65c | 35 40 1 | 118 17 5 | 2,716.9 | |
| 122 | Cook's Point ....... | ....do ....... | 73a | 35 37 9 | 118 26 30 | *6,336 | |
| 123 | Disappointment .... | ....do ....... | 73c | 34 14 50 | 118 6 55 | ......... | |
| 124 | Nichols's Point..... | ....do ....... | 73a | 35 37 0 | 118 18 5 | *6,263 | |
| 125 | Pahute............. | ....do ....... | 73a | 35 28 37 | 118 21 50 | 8,342.0 | |
| 126 | Tehachapai Double. | ....do ....... | 73a | 35 1 47 | 118 29 25 | *8,263 | |
| 127 | White Granite ..... | ....do ....... | 73c | 34 36 34 | 119 7 55 | 7,045.0 | |
| 128 | Workman's Hill .. | ....do ....... | 73c | 34 0 48 | 118 1 14 | 1,363.7 | |
| | Primary triangulation stations: | ............... | 80 | ......... | ......... | ......... | Do. |
| 129 | San Jacinto ........ | California... | 80b | 33 48 59 | 116 42 16 | 10,987.3 | |
| 130 | Temescal (1)....... | ....do ....... | 80b | 33 42 31 | 117 32 4 | *5,730 | |
| | Secondary triangulation station: | ............... | 80 | ......... | ......... | ......... | Do. |
| 131 | San Pedro Hill ..... | California... | 80a | 33 44 39 | 118 20 8 | 1,462.3 | |
| | Primary triangulation stations: | ............... | 61 | ......... | ......... | ......... | Triangulation sheet No. 19. |
| 132 | Blanco ............. | Colorado.... | 62c | 37 34 37 | 105 28 57 | 14,269.9 | |
| 133 | Del Norte.......... | ....do ....... | 61d | 37 28 58 | 106 25 53 | 13,084.1 | |
| 134 | Dunn's ............ | ....do ....... | 61c | 37 50 24 | 108 5 37 | 13,502.4 | |
| 135 | Hunt's ............. | ....do ....... | 61b | 38 25 20 | 106 13 18 | 14,054.6 | |
| 136 | La Plata ........... | ....do ....... | 61c | 37 26 41 | 108 5 10 | 13,316.0 | |
| 137 | Mear's ............ | ....do ....... | 61c | 38 1 50 | 107 54 23 | 13,008.9 | |
| 138 | Pagosa ............ | ....do ....... | 61c | 37 26 37 | 107 3 50 | 12,675.8 | |
| 139 | Simpson ........... | ....do ....... | 61c | 37 40 46 | 107 23 22 | 14,055.9 | |
| 140 | Uncompahgre ...... | ...do ....... | 61c | 38 4 18 | 107 27 33 | 14,408.4 | |
| | Secondary triangulation stations: | ............... | 61 | ......... | ......... | ......... | Do. |
| 141 | Æolus.............. | Colorado .... | 61c | 37 37 39 | 107 36 15 | *14,211.0 | |
| 142 | Agency Knob ...... | ...do ....... | 61b | 38 16 24 | 106 51 54 | 12,273.5 | |
| 143 | Bristol Head ........ | ....do ....... | 61c | 37 47 33 | 107 3 2 | *12,637.7 | |
| 144 | Buffalo............. | ....do ....... | 61c | 37 36 24 | 107 29 27 | 13,755.5 | |
| 145 | Canby.............. | ....do ....... | 61c | 37 46 54 | 107 30 50 | 13,356.0 | |
| 146 | Carbon.............. | ....do ....... | 61a | 38 47 39 | 107 2 24 | 12,078.2 | |
| 147 | Del Norte Hill ...... | ... do ....... | 61d | 37 40 14 | 106 21 26 | 8,218.3 | |
| 148 | Elk ................ | ....do ....... | 61a | 38 43 4 | 107 11 47 | 13,101.6 | |
| 149 | Engineer............ | ....do ....... | 61c | 37 41 57 | 107 48 14 | 13,277.4 | |
| 150 | Glacier............. | ... do ....... | 61c | 37 50 21 | 107 59 20 | 14,243.0 | |
| 151 | Grand Mesa......... | ....do ....... | 61a | 38 53 34 | 108 10 26 | ......... | |
| 152 | Handie.............. | ....do ....... | 61c | 37 54 46 | 107 30 6 | 14,149.0 | |
| 153 | Horsefly............ | ....do ....... | 61a | 38 11 43 | 107 55 40 | 10,504.5 | |
| 154 | Leon ............... | ....do ....... | 52c | 39 4 45 | 107 50 27 | 11,218.4 | |
| 155 | Macomb's.......... | ....do ....... | 61c | 37 34 25 | 106 58 43 | 13,154.2 | |
| 156 | Meigs' ............ | ....do ....... | 61d | 37 21 1 | 106 41 39 | 13,393.5 | |
| 157 | Observatory Cone... | ....do ....... | 61b | 38 34 41 | 106 51 37 | ......... | |
| 158 | Pole Creek.......... | ....do ....... | 61c | 37 47 30 | 107 25 26 | ......... | |
| 159 | Red Cloud.......... | ....do ....... | 61c | 37 56 27 | 107 25 8 | 14,092.6 | |
| 160 | Sultan ............. | ....do ....... | 61c | 37 47 10 | 107 42 4 | *13,501.0 | |
| 161 | Wetterhorn ......... | ....do ....... | 61c | 38 3 38 | 107 30 29 | *14,062.0 | |
| 162 | Blaine's ........... | ....do ....... | 61c | 38 0 14 | 107 47 22 | *14,249.0 | |
| | Primary triangulation stations: | ............... | 69 | ......... | ......... | ......... | Do. |
| 163 | Banded............. | Colorado .... | 69b | 37 6 16 | 106 37 27 | 12,824.4 | |
| 164 | Las Truchas ....... | New Mexico | 69d | 35 57 41 | 105 38 39 | *13,150.0 | |
| 165 | Santa Clara......... | ....do ....... | 69d | 36 0 26 | 106 22 54 | *11,507.0 | |
| 166 | Santa Fé Baldy ..... | ....do ....... | 69d | 35 49 51 | 105 45 26 | 12,661.2 | |
| 167 | Taos ............... | ....do ....... | 70a | 36 33 23 | 105 24 51 | 13,097.9 | |
| | Secondary triangulation stations: | ............... | 84 | ......... | ......... | ......... | Triangulation sheet No. 20. |
| 168 | Black ............... | New Mexico | 84c | 32 54 23 | 108 10 8 | 8,909.8 | |
| 169 | Caballo Cone ...... | ....do ....... | 84c | 33 6 1 | 107 14 3 | ......... | |
| 170 | East Carrizo Cone.. | ....do ....... | 84b | 33 39 0 | 105 37 17 | 7,975.7 | |
| 171 | Horse ............... | ....do ....... | 84a | 33 58 36 | 108 7 50 | ......... | |
| 172 | Organ .............. | ....do ....... | 84d | 32 20 41 | 106 34 6 | *9,108.0 | |
| 173 | Round .............. | ....do ....... | 84a | 33 40 26 | 108 6 28 | ......... | |
| 174 | Sunday Cone ....... | ....do ....... | 84c | 32 37 6 | 107 27 14 | 6,030.3 | |

*List of Triangulation Stations*—Continued.

| Number. | Name of peak. | State or Territory. | Atlas sheet. | Latitude. | Longitude. | Altitude. | Remarks. |
|---|---|---|---|---|---|---|---|
| | | | | ° ′ ″ | ° ′ ″ | | |
| | Primary triangulation stations: | | 89 | | | | Triangulation sheet No. 21. |
| 175 | Hacheta | New Mexico | 89*b* | 31 37 56 | 108 24 18 | 8,352.3 | |
| | Secondary triangulation stations: | | .. | | | | Do. |
| 176 | Lolacha | New Mexico | 89*b* | 31 50 19 | 108 27 34 | | |
| | Primary triangulation stations: | | 90 | | | | Do. |
| 177 | Florida | New Mexico | 90*a* | 32 7 16 | 107 37 40 | 7,295.4 | |
| 178 | Mexico | Chihuahua | 90*b* | 31 43 14 | 106 34 54 | | |
| 179 | North Franklin | Texas | 90*b* | 31 54 7 | 106 29 24 | 7,069.5 | |
| 180 | South Franklin | do | 90*b* | 31 48 15 | 106 28 47 | | |
| | Secondary triangulation stations: | | | | | | Do. |
| 181 | Boca Grande | Chihuahua | 90*a* | 31 37 46 | 107 59 59 | | |
| 182 | Boundary Monument | | 90*b* | 31 46 58 | 106 32 1 | 4,443.8 | |
| 183 | Graveyard Hill | Texas | 90*b* | 31 45 52 | 106 29 41 | | |
| 184 | Initial Monument | | 90*b* | 31 46 58 | 106 31 34 | | |
| 185 | Potrillo | New Mexico | 90*a* | 31 55 21 | 107 4 7 | | |
| 186 | Rodadero | do | 90*b* | 31 47 11 | 106 32 32 | | |
| | Primary triangulation stations: | | 47 | | | | Triangulation sheet No. 7. |
| 187 | Genoa | Nevada | 47*d* | 39 2 26 | 119 52 43 | | |
| 188 | Lyon | do | 47*d* | 39 7 33 | 119 28 12 | 8,793.5 | |
| | Secondary triangulation stations: | | 47 | | | | Do. |
| 189 | Butt Mountain | California | 47*a* | 40 12 58 | 121 23 2 | 7,830.6 | |
| 190 | Mount Dyer | do | 47*a* | 40 14 15 | 121 1 48 | 7,369.2 | |
| 191 | Kettle Rock | do | 47*a* | 40 8 42 | 120 43 3 | 7,843.4 | |
| 192 | Schaffer's | do | 47*b* | 40 26 43 | 120 21 18 | 6,864.5 | |
| 193 | McKesick's | do | 47*b* | 40 5 23 | 120 14 43 | 7,083.0 | |
| 194 | State Line | Nevada | 47*b* | 40 1 44 | 119 58 32 | 8,405.2 | |
| 195 | Omjumi | California | 47*b* | 39 56 17 | 120 16 56 | 8,292.6 | |
| 196 | Adams | do | 47*b* | 39 54 32 | 120 5 43 | 8,431.6 | |
| 197 | Wellington | do | 47*b* | 39 52 0 | 120 31 41 | 7,664.6 | |
| 198 | Haskell's | do | 47*d* | 39 39 41 | 120 33 1 | 8,126.4 | |
| 199 | Crystal | do | 47*d* | 39 28 21 | 120 2 13 | | |
| 200 | N. E. Base | Nevada | 47*d* | 39 25 44 | 119 25 39 | 7,099.9 | |
| 201 | Tibbie | do | 47*d* | 39 22 8 | 119 31 54 | 7,383.3 | |
| 202 | Rocky Point | do | 47*d* | 39 20 50 | 119 34 2 | | |
| 203 | Davidson | do | 47*d* | 39 18 22 | 119 39 37 | 7,941.2 | |
| 204 | Emma | do | 47*d* | 39 17 39 | 119 36 1 | 6,439.4 | |
| 205 | McClellan | do | 47*d* | 39 15 26 | 119 41 46 | 7,531.6 | |
| 206 | Raw | do | 47*d* | 39 11 56 | 119 28 40 | 8,403.8 | |
| 207 | Como | do | 47*d* | 39 1 8 | 119 28 14 | 9,016.6 | |
| 208 | Churchill Butte | do | 47*d* | 39 20 16 | 119 17 32 | 6,009.0 | |
| | Primary triangulation stations: | | 48 | | | | Do. |
| 209 | Tutib | Nevada | 48*c* | 39 42 53 | 119 9 46 | 7,062.1 | |
| 210 | Tarogqua | do | 48*c* | 39 34 52 | 118 13 54 | 8,771.7 | |
| 211 | Grant | do | 48*c* | 39 32 16 | 117 54 56 | 9,964.8 | |
| 212 | Desatoya | do | 48*d* | 39 21 47 | 117 45 19 | 9,921.3 | |
| 213 | Bunker Hill | do | 48*d* | 39 15 2 | 117 7 18 | 11,404.5 | |
| 214 | Fairview | do | 48*c* | 39 13 22 | 118 8 55 | 8,411.5 | |
| | Secondary triangulation stations: | | 48 | | | | Do. |
| 215 | Emigrant | Nevada | 48*d* | 39 24 7 | 117 23 24 | 8,508.5 | |
| 216 | Geneva | do | 48*d* | 39 21 27 | 117 4 14 | 11,077.1 | |
| 217 | Birchim's | do | 48*d* | 39 8 53 | 117 28 33 | 10,343.9 | |
| 218 | Cowles' | do | 48*d* | 39 3 14 | 117 33 25 | 9,980.1 | |
| | Secondary triangulation stations: | | 76 | | | | Triangulation sheet No. 20. |
| 219 | Alamocita | Arizona | 76*d* | 34 11 56 | 108 28 17 | | |
| | Primary triangulation stations: | | 77 | | | | Do. |
| 220 | Bernal Hill | New Mexico | 78*a* | 35 22 33 | 105 19 38 | | |
| 221 | Escobas | do | 77*b* | 35 32 2 | 105 42 45 | | |
| 222 | Ladrones | do | 77*c* | 34 26 1 | 107 5 29 | 9,214.3 | |
| 223 | Manzano | do | 77*d* | 34 35 23 | 106 27 13 | 10,086.3 | |
| 224 | Mosca | do | 77*d* | 34 48 36 | 106 24 34 | 9,723.0 | |
| 225 | Osha | do | 77*d* | 34 38 9 | 106 26 44 | 10,022.8 | |
| 226 | Pedernal | do | 77*b* | 34 50 38 | 105 39 4 | 7,580.3 | |
| 227 | Placer | do | 77*b* | 35 20 3 | 106 10 36 | 8,965.2 | |
| 228 | Rattlesnake Hill | do | 77*d* | 34 34 7 | 105 49 41 | 6,616.5 | |
| 239 | Taylor | do | 77*a* | 35 14 16 | 107 36 55 | 11,391.2 | |
| 230 | Tecolote | do | 77*d* | 34 4 37 | 105 41 44 | 7,253.7 | |
| 231 | Tetilla | do | 77*b* | 35 36 24 | 106 13 1 | 7,060.0 | |

*List of Triangulation Stations*—Continued.

| Number. | Name of peak. | State or Territory. | Atlas-sheet. | Latitude. | Longitude. | Altitude. | Remarks. |
|---|---|---|---|---|---|---|---|
| | | | | ° ′ ″ | ° ′ ″ | | |
| | Primary triangulation stations: | | 83 | | | | Triangulation sheet No. 20. |
| 232 | Bear | New Mexico | 83*d* | 32 49 58 | 108 21 52 | 8,081.1 | |
| 233 | Eagle | ...do | 83*b* | 33 40 30 | 108 35 2 | | |
| 234 | Thomas | Arizona | 83*b* | 33 54 21 | 109 34 34 | *11,275 | |
| | Secondary triangulation stations: | | | | | | Do. |
| | Graham | Arizona | 83*c* | 32 41 56 | 109 52 40 | 10,099.5 | |
| | Primary triangulation stations: | | 84 | | | | Do. |
| 235 | Capitan | New Mexico | 85*a* | 33 35 24 | 105 16 20 | 10,022.9 | |
| 236 | Colorado | ...do | 84*b* | 33 50 42 | 106 42 6 | 5,653.7 | |
| 237 | Cook | ...do | 84*c* | 32 32 6 | 107 44 15 | 8,329.6 | |
| 238 | Fra Cristobal | ...do | 84*a* | 33 25 35 | 107 7 10 | 6,646.2 | |
| 239 | Magdalena | ...do | 84*a* | 33 59 23 | 107 11 39 | 10,798.0 | |
| 240 | Nogal | ...do | 84*b* | 33 29 47 | 105 48 36 | 9,983.0 | |
| 241 | Salinas | ...do | 84*b* | 33 17 51 | 106 32 15 | 9,039.5 | |
| 242 | San Mateo | ...do | 84*a* | 33 33 7 | 107 26 27 | 10,208.6 | |
| 243 | Sierra Blanca | ...do | 84*b* | 33 22 24 | 105 48 55 | 11,892.3 | |

The altitudes of all points marked thus (*) are from angles of elevation; all others are from barometric determinations.

## BAROMETRIC HYPSOMETRY.

The usual plan for obtaining the vertical element of the greater share of observation points by means of barometric differences in altitude has been pursued. The computations have been for another year under the supervision of Lieutenant Tillman. Satisfactory results have been obtained. As heretofore, through the courtesy of General Myer, Chief Signal Officer, transcripts of the observations of the Signal Service at specified points have been furnished. Lists of altitudes prepared by Lieutenant Tillman of points of special importance in the areas of 1878 are to be found herewith.

*List of Altitudes.*

| Number. | Locality. | State or Territory. | Atlas-sheet. | Number of observations. | Reference station. | Altitude above sea-level. |
|---|---|---|---|---|---|---|
| | | | | | | *Feet.* |
| 1 | Walla Walla | Washington T. | 12*c* | D. M. | Portland | 1,033.5 |
| 2 | North Base at Dalles | Oregon | 20*a* | 5 | ...do | 187.5 |
| 3 | Astronomical Station at Dalles | ...do | 20*a* | 5 | ...do | 134.7 |
| 4 | South Base | ...do | 20*a* | 5 | ...do | 215.4 |
| 5 | Dalles Hill | ...do | 20*a* | 6 | ...do | 1,210.1 |
| 6 | Shivar's Bridge, Deschutes River | ...do | 20*a* | 4 | ...do | 702.0 |
| 7 | Finnegan's Ranch, Military Road | ...do | 20*a* | 2 | ...do | 2,143.7 |
| 8 | Cross Hollows | ...do | 20*a* | 4 | ...do | 3,197.3 |
| 9 | Divide on Shivar's Road, between John Day and Deschutes Rivers. | ...do | 20*a* | 1 | ...do | 3,515.0 |
| 10 | Divide on O-cho-co and Cross Hollow, between John Day and Deschutes Rivers. | ...do | 20*a* | 1 | ...do | 3,354.5 |
| 11 | Divide, Head Antelope Valley, between John Day and Deschutes Rivers. | ...do | 20*a* | 1 | ...do | 3,298.2 |
| 12 | Antelope Post Office | ...do | 20*a* | 2 | ...do | 2,844.5 |
| 13 | Divide, Cañon City Road, between John Day and Deschutes Rivers. | ...do | 20*a* | 1 | ...do | 3,694.7 |

*List of Altitudes*—Continued.

| Number. | Locality. | State or Territory. | Atlas-sheet. | Number of observations. | Reference station. | Altitude above sea-level. |
|---|---|---|---|---|---|---|
| | | | | | | *Feet.* |
| 14 | Camas Prairie | Oregon | 20*a* | 2 | Portland | 3,019.8 |
| 15 | Big Prairie | ...do | 20*a* | 4 | ...do | 3,334.8 |
| 16 | Summit Prairie | ...do | 20*a* | 4 | ...do | 3,694.2 |
| 17 | Upper Cascade | ...do | 20*a* | 6 | ...do | 126.6 |
| 18 | Deschutes Bridge | ...do | 20*a* | 2 | ...do | 165.8 |
| 19 | Grant's Landing | ...do | 20*a* | 4 | ...do | 336.4 |
| 20 | Barnum's Ranch | ...do | 20*a* | 2 | ...do | 1,795.2 |
| 21 | Mutton Mountain | ...do | 20*a* | 2 | ...do | 3,692.9 |
| 22 | The Dalles | ...do | 20*a* | D. M. | ...do | 179.8 |
| 23 | Currant Creek Stage Station | ...do | 20*b* | 4 | ...do | 2,142.0 |
| 24 | Burnt Ranch, John Day River | ...do | 20*b* | 2 | ...do | 1,561.3 |
| 25 | Carmical's Ranch | ...do | 20*c* | D. M. and 4 | Portland and Red Bluff. | 2,736.2 |
| 26 | Warm Spring Indian Agency | ...do | 20*c* | ...... | Portland | 1,513.9 |
| 27 | Warm Springs | ...do | 20*c* | 1 | ...do | 1,529.1 |
| 28 | Klikatat Hill | ...do | 20*c* | 4 | ...do | 3,069.6 |
| 29 | Deschutes River Bridge | ...do | 20*c* | 2 | ...do | 2,563.0 |
| 30 | Parrish Ranch | ...do | 20*c* | 2 | ...do | 3,330.2 |
| 31 | Fish Lake | ...do | 20*c* | 2 | ...do | 3,154.8 |
| 32 | Prineville | ...do | 20*c* | 4 | Red Bluff | 2,899.0 |
| 33 | Green's Ranch | ...do | 20*c* | 6 | Winnemucca | 4,470.0 |
| 34 | Lodge Pole Spring | ...do | 20*c* | 2 | Portland | 1,648.3 |
| 35 | Mud Springs | ...do | 20*c* | 2 | Red Bluff | 2,443.4 |
| 36 | Hald's Ranch | ...do | 20*d* | 2 | Portland | 3,286.6 |
| 37 | Big Summit Prairie | ...do | 20*d* | 2 | Winnemucca | 5,123.8 |
| 38 | North Twin Lake | ...do | 28*d* | 1 | Red Bluff | *5,117.1 |
| 39 | Mount Pitt | ...do | 28*d* | 4 | ...do | 9,817.5 |
| 40 | Union Peak | ...do | 28*d* | 3 | ...do | 7,298.1 |
| 41 | Mount Scott | ...do | 28*d* | 6 | ...do | 9,015.5 |
| 42 | Summit of road to Crater Lake | ...do | 28*d* | 2 | ...do | 6,412.4 |
| 43 | Crater Lake | ...do | 28*d* | 5 | ...do | 7,143.0 |
| 44 | Corral Springs | ...do | 28*b* | 2 | ...do | 4,568.7 |
| 45 | Edge of Summit Lake | ...do | 28*b* | 1 | ...do | 5.610.1 |
| 46 | Diamond Peak | ...do | 28*b* | 2 | ...do | 8,806.6 |
| 47 | North end of Davis Lake | ...do | 28*b* | 2 | ...do | 4,466.0 |
| 48 | Farewell Bend, Deschutes River | ...do | 29*a* | 2 | Portland and Red Bluff. | 3,620.9 |
| 49 | Langden's Ranch | ...do | 29*a* | 2 | Winnemucca | 5,162.9 |
| 50 | Button's Ranch | ...do | 29*a* | 2 | ...do | 4.236.7 |
| 51 | "Halfway," on East Deschutes River | ...do | 29*a* | 4 | Red Bluff | 4,081.1 |
| 52 | Fall Creek Cascade | ...do | 29*a* | 2 | Camp 8 | 4.177.8 |
| 53 | Little Prairie | ...do | 29*a* | 2 | ...do | 4.428.0 |
| 54 | Big Meadows | ...do | 29*a* | D. M. | Red Bluff | 4,123.7 |
| 55 | Dillard & Renshaw's Ranch | ...do | 29*b* | 2 | Winnemucca | 4,656.6 |
| 56 | Curry Spring | ...do | 29*b* | 2 | ...do | 4,272.9 |
| 57 | Hoskin's Ranch, Silver Creek | ...do | 29*b* | 2 | ...do | 4,139.1 |
| 58 | Head of Chewaucan Marsh | ...do | 29*c* | 2 | ...do | 4,336.0 |
| 59 | Bratton's Ranch | ...do | 29*c* | D. M. | ...do | 4,495.4 |
| 60 | Timber Mountain | ...do | 29*c* | 4 | Camp 7 | 7,518.8 |
| 61 | Summer Lake (water's edge) | ...do | 29*c* | 1 | Winnemucca | 4,163.2 |
| 62 | Foster's Ranch, on Summer Lake | ...do | 29*c* | 2 | ...do | 4,174.3 |
| 63 | South end Sikan Marsh | ...do | 29*c* | 5 | ...do | 4,959.9 |
| 64 | Klamath Reservation | ...do | 29*c* | 2 | ...do | 4,943.9 |
| 65 | Fort Klamath | ...do | 29*c* | ........ | ...do | 4,108.4 |
| 66 | Klamath Marsh | ...do | 29*c* | 1 | Red Bluff | 4,371.1 |
| 67 | Durand's Ranch | ...do | 29*c* | 2 | Winnemucca | 4,312.0 |
| 68 | Parton's Ranch | ...do | 29*c* | 2 | ...do | 4,497.6 |
| 69 | Miller's Ranch | ...do | 29*c* | 2 | ...do | 4,420.8 |
| 70 | Big Springs | ...do | 29*c* | 2 | Red Bluff | 4,552.5 |
| 71 | Corral Spring | ...do | 29*c* | D. M. | ...do | 4,782.6 |
| 72 | Pauline Peak | ...do | 29*c* | 1 | ...do | 7,387.2 |
| 73 | Camp Warner | ...do | 29*d* | 2 and 3 | Winnemucca | 5,730.3 |
| 74 | Alkaline Desert | ...do | 29*d* | 1 | ...do | 4,283.8 |
| 75 | North end of Albert Alkaline Lake | ...do | 29*d* | 2 | ...do | 4,208.7 |
| 76 | Mule Spring | ...do | 29*d* | 2 | ...do | 4,738.5 |
| 77 | Warner Lake Flat | ...do | 29*d* | 2 | ...do | 4,543.6 |
| 78 | Jones' Ranch, Honey Creek | ...do | 29*d* | D. M., and 2. | ...do | 4,466.0 |
| 79 | Moss's Ranch | ...do | 29*d* | 2 | ...do | 4,827.8 |
| 80 | Mesa Summit, west of Warner Valley | ...do | 29*d* | 1 | ...do | 4,894.0 |
| 81 | Drew Valley post-office | Oregon | 38*a* | 1 | Camp 40 | 4,952.6 |
| 82 | Lo-lo-che-wis Peak | ...do | 38*a* | 3 | Winnemucca | 7.957.2 |
| 83 | Sugar Loaf Mountain | California | 38*b* | ........ | Winnemucca and camp 45. | 8,415.6 |

*List of Altitudes*—Continued.

| Number. | Locality. | State or Territory. | Atlas-sheet. | Number of observations. | Reference station. | Altitude above sea-level. |
|---|---|---|---|---|---|---|
| | | | | | | *Feet.* |
| 84 | Wallace's Ranch, Warner Lake | California | 38*b* | 2 | Winnemucca | 4. 486. 8 |
| 85 | Camp Bidwell | do | 38*b* | | | 4, 647. 0 |
| 86 | Cow Head Lake Spring | do | 38*b* | 2 | Winnemucca | 5, 329. 4 |
| 87 | Cow Head Lake | do | 38*b* | 2 | do | 6, 041. 2 |
| 88 | Lakeview | do | 38*b* | | do | 4, 851. 0 |
| 89 | Cedarville Pass, summit of | Oregon | 38*b* | 1 | do | 6, 355. 6 |
| 90 | Cedarville, Surprise Valley | do | 38*b* | 1 and 3 | do | 4, 674. 5 |
| 91 | Cedar Peak Valley | do | 38*b* | 3 | do | 8, 308. 1 |
| 92 | Fletcher's Ranch Valley | do | 38*b* | 2 | do | 4, 819. 4 |
| 93 | Goose Lake, west edge Valley | do | 38*b* | 1 | do | 4, 697. 0 |
| 94 | North End Peak | do | 38*b* | 3 | Winnemucca and camp 47. | 8, 471. 6 |
| 95 | Fandango Peak | California | 38*b* | 3 | Camp 48 | 7, 848. 5 |
| 96 | Lake City Pass | do | 38*b* | 1 | Winnemucca | 7, 034. 5 |
| 97 | Lake City | do | 38*b* | 1 | do | 4, 623. 5 |
| 98 | Mount Bidwell | do | 38*b* | 3 | Camp Bidwell, | 8, 551. 2 |
| 99 | "Forty-nine" Cañon Pass | Nevada | 38*b* | 1 | Winnemucca | 6, 305. 8 |
| 100 | Fredonyer's Peak | California | 38*d* | 7 | Winnemucca and camp 15. | 7, 995. 2 |
| 101 | Shinn's Ranch | do | 38*d* | 3 | Winnemucca | 5, 040. 4 |
| 102 | Horn Spring | do | 38*d* | 3 | do | 5, 476. 5 |
| 103 | Observation Peak | do | 38*d* | 3 | do | 8, 009. 3 |
| 104 | Harris's Ranch, Madeline Plains | do | 38*d* | 1 | do | 5, 338. 6 |
| 105 | Cold Spring Valley | do | 38*d* | D. M. | do | 5, 375. 7 |
| 106 | McDonald Peak | do | 38*d* | 3 | Camp 23 | 7, 954. 0 |
| 107 | McDonald's Ranch | do | 38*d* | 1 | do | 5, 297. 0 |
| 108 | Madeline Hat Peak | do | 38*d* | 2 | Camp 27 | 7, 676. 1 |
| 109 | Tule Flat | do | 38*d* | 3 | Winnemucca | 5, 594. 7 |
| 110 | Clear Lake | do | 38*d* | 2 | do | 5, 807. 9 |
| 111 | Warren's Peak | do | 38*d* | 3 | Camp 33 | 9, 668. 0 |
| 112 | Alturas | do | 38*d* | 5 | Winnemucca | 4, 364. 9 |
| 113 | Eagleville | do | 38*d* | 2 | do | 4, 632. 5 |
| 114 | Middle Lake, Surprise Valley | do | 38*d* | 1 | do | 4, 551. 4 |
| 115 | Dry Flat, mouth High Rock Cañon | Nevada | 38*d* | 1 | do | 4, 966. 8 |
| 116 | Division Peak | do | 38*d* | 3 | do | 8, 584. 7 |
| 117 | Barkley Spring | do | 38*d* | 5 | do | 5, 905. 8 |
| 118 | Mouth of Cottonwood Cañon | do | 38*d* | 8 | do | 6, 065. 7 |
| 119 | North Granite Peak | do | 38*d* | 3 | do | 8, 363. 1 |
| 120 | Pinto Spring | do | 38*d* | 5 | do | 5, 638. 8 |
| 121 | Monument Hill | do | 38*d* | 3 | Camp 63 | 6, 734. 3 |
| 122 | Todhunter's Camp, Long Valley | do | 33*d* | 1 | Winnemucca | 5, 779. 2 |
| 123 | Todhunter's Ranch | do | 38*d* | 1 | do | 5, 850. 9 |
| 124 | Bare's Ranch, Surprise Valley | California | 38*d* | 2 | do | 4, 679. 6 |
| 125 | Clark's Ranch | Nevada | 38*d* | 2 | do | 4, 676. 8 |
| 126 | Granite Peak | do | 38*d* | 3 | Camp 70 and Sacramento. | 8, 990. 1 |
| 127 | Wall Spring | do | 38*d* | 2 | Winnemucca | 3, 912. 2 |
| 128 | Mud Meadows | do | 39*c* | 5 | do | 4, 318. 0 |
| 129 | Pah-Ute Peak | do | 39*c* | 3 | do | 8, 618. 2 |
| 130 | Jelley's Ranch | California | 46*b* | D. M. | Red Bluff | 360. 0 |
| 131 | Cohen's Ranch | do | 46*b* | D. M. | do | 280. 7 |
| 132 | Sesma Station | do | 46*b* | D. M. | do | 259. 7 |
| 133 | Doon's Saw Mill | do | 47*a* | 2 | do | 3, 420. 2 |
| 134 | Old Kimshew Settlement | do | 47*a* | 3 | do | 4, 991. 9 |
| 135 | Cress's Ranch | do | 47*a* | D. M. and 3 | do | 5, 157. 0 |
| 136 | American Valley, ½ mile north of Quincy | do | 47*a* | D. M. | do | 3, 374. 4 |
| 137 | Orchard near Kingsbury's Mining Claim | do | 47*a* | 2 | do | 2, 678. 4 |
| 138 | Caribou Bridge, North Fork | do | 47*a* | 1 | do | 2, 843. 4 |
| 139 | Miller's Ranch | do | 47*a* | 2 | do | 4, 055. 1 |
| 140 | Butte Creek House | do | 47*a* | D. M. | do | 5, 758. 1 |
| 141 | Lott's Diggings | do | 47*a* | 1 | do | 6, 309. 6 |
| 142 | Head of Chip Creek | do | 47*a* | D. M. | do | 5, 953. 7 |
| 143 | Inskip Toll Gate | do | 47*a* | 4 | do | 4, 808. 3 |
| 144 | Forest Ranch | do | 47*a* | 2 | do | 2, 217. 4 |
| 145 | Lomo | do | 47*a* | 3 | do | 3, 847. 8 |
| 146 | Colby's Ranch | do | 47*a* | D. M. | do | 4, 989. 7 |
| 147 | Toll Gate | do | 47*a* | 4 | do | 5, 426. 6 |
| 148 | Deer Creek Meadows | do | 47*a* | D. M. | do | 4, 518. 1 |
| 149 | Butt Mountain | do | 47*a* | 4 | do | 7, 830. 6 |
| 150 | Prattville | do | 47*a* | | do | 4, 394. 1 |
| 151 | Geysers | do | 47*a* | 1 | do | 5, 864. 0 |
| 152 | Solfatara | do | 47*a* | 1 | do | 5, 907. 8 |
| 153 | Hot Springs | do | 47*a* | 1 | do | 6, 080. 2 |

*List of Altitudes*—Continued.

| Number. | Locality. | State or Territory. | Atlas-sheet. | Number of observations. | Reference station. | Altitude above sea-level. |
|---|---|---|---|---|---|---|
| | | | | | | *Feet.* |
| 154 | Martin's Ranch | California | 47*a* | 2 | Red Bluff | 4,484.0 |
| 155 | Nash's Ranch | do | 47*a* | D. M. | do | 4,431.3 |
| 156 | Mount Dyer, near Big Meadows | do | 47*a* | 4 | do | 7,369.2 |
| 157 | Willow Lake | do | 47*a* | 2 | do | 5,382.2 |
| 158 | Lassen's Butte | do | 47*a* | | Prattville and Red Bluff. | 10,437.0 |
| 159 | Mount Harkness, near Big Meadows | do | 47*a* | 1 | do | *8,675.3 |
| 160 | Dutch Hill Mining Camp | do | 47*a* | 1 | do | 4,692.3 |
| 161 | Grizzly Hill | do | 47*a* | 1 | do | *5,708.9 |
| 162 | Greenville | do | 47*a* | 1 | do | 3,543.8 |
| 163 | Forgay's Ranch | do | 47*a* | 4 | do | 3,380.6 |
| 164 | Jim Ford's Ranch | do | 47*a* | 2 | do | 3,518.5 |
| 165 | Johnson's Ranch | do | 47*a* | 4 | do | 4,378.8 |
| 166 | Peter Lassen's Grave, Henry Lake Valley | do | 47*a* | 1 | do | 4,280.9 |
| 167 | Stockton Mill | do | 47*a* | 3 | do | 4,639.3 |
| 168 | Goodrich's Ranch | do | 47*a* | 6 and 2 | do | 4,883.0 |
| 169 | Mitchell's Ranch | do | 47*a* | 2 | do | 4,284.6 |
| 170 | Peach Spring | do | 47*a* | D. M. | do | 5,303.2 |
| 171 | Upper edge of crater—cinder cone | do | 47*a* | 1 | do | 6,741.3 |
| 172 | Bottom of crater | do | 47*a* | 1 | do | 6,596.3 |
| 173 | Foot of slope of cone | do | 47*a* | 1 | do | 6,512.2 |
| 174 | Second lake east of cone | do | 47*a* | 1 | do | 6,085.2 |
| 175 | Divide, Noble Pass | do | 47*a* | 1 | do | 5,963.0 |
| 176 | Loomis's Ranch | do | 47*a* | D. M. | do | 4,356.5 |
| 177 | Quincy | do | 47*a* | | do | *3,381.0 |
| 178 | Ogburn's Ranch | do | 47*a* | D. M. | Red Bluff | *2,269.5 |
| 179 | Wilson's Ranch | do | 47*a* | 2 | do | 1,114.5 |
| 180 | Hickman's Ranch | do | 47*a* | 5 | do | 1,906.8 |
| 181 | Toll Gate, Battle Creek Road | do | 47*a* | 7 | do | 4,699.7 |
| 182 | Gray's Ranch | do | 47*a* | 2 | do | 3,388.0 |
| 183 | Hart's Ranch | do | 47*a* | 2 | do | 1,099.7 |
| 184 | Phillips' Ranch | do | 47*a* | D. M. | do | 242.1 |
| 185 | Claremont Hill south of Quincy | do | 47*a* | 4 | do | 6,998.6 |
| 186 | Old Toll House, between Quincy and Taylorsville. | do | 47*a* | 3 | do | 5,509.9 |
| 187 | Hough's Mountain | do | 47*a* | 1 | do | *7,390.7 |
| 188 | Taylorsville | do | 47*a* | 1 | do | 3,521.5 |
| 189 | Kettle Rock Peak | do | 47*a* | 2 | do | 7,843.4 |
| 190 | Parker's Ranch | do | 47*a* | 2 | do | 4,135.7 |
| 191 | Divide between Kingsbury's Ranch and Caribou Bridge. | do | 47*a* | 1 | do | 4,628.0 |
| 192 | Main divide between Miller's and Longville (on road.) | do | 47*a* | 1 | do | 5,091.6 |
| 193 | Longville | do | 47*a* | | do | *4,309.0 |
| 194 | Main divide between Longville and Butte Creek House. | do | 47*a* | 1 | do | 6,706.2 |
| 195 | Divide between Colby's and Toll Gate | do | 47*a* | | do | 6,618.7 |
| 196 | Bridge over Butte Creek (7½ miles from Prattville.) | do | 47*a* | 1 | do | 4,691.6 |
| 197 | Moonlight Valley | do | 47*a* | | do | 5,433.3 |
| 198 | Taylorville to Susanville, main divide | do | 47*a* | | do | 6,428.1 |
| 199 | Susanville Post-office | do | 47*a* | 7 | American Flat | 4,195.2 |
| 200 | First divide, between Susanville and Eagle Lake. | do | 47*a* | 1 | Winnemucca | 5,362.8 |
| 201 | Second divide, between Susanville and Eagle Lake. | do | 47*a* | 1 | do | 5,773.7 |
| 202 | Main divide, between Susanville and Eagle Lake. | do | 47*a* | 1 | do | 6,245.0 |
| 203 | Eagle Lake | do | 47*a* | D.M.&2 | do | 5,114.5 |
| 204 | Willow Spring (head Willow Creek) | do | 47*a* | 1 | do | 5,083.9 |
| 205 | Honey Lake | do | 47*b* | 1 | Carson City | 3,948.6 |
| 206 | Adam's Peak | do | 47*b* | 8 | Camp 6 | 8,431.6 |
| 207 | Mape's Ranch | do | 47*b* | 3 | Carson City | 5,038.7 |
| 208 | Crow's Ranch, Clover Valley | do | 47*b* | D. M. | do | 5,464.0 |
| 209 | Keg Spring, Willow Creek | do | 47*b* | 2 | Crow's Ranch | 5,756.8 |
| 210 | McKesick's Peak | do | 47*b* | 3 | do | 7,083.0 |
| 211 | Omjumi Peak | do | 47*b* | 8 | Crow's Ranch and Carson City. | 8,292.6 |
| 212 | Frenchman's Cove | do | 47*b* | 4 | Crow's Ranch | 5,564.7 |
| 213 | Mount Ingalls | do | 47*b* | 9 | Crow's Ranch and Carson City. | 8,471.5 |
| 214 | Mount Wellington | do | 47*b* | 5 | Crow's Ranch | 7,664.6 |

*List of Altitudes*—Continued.

| Number. | Locality. | State or Territory. | Atlas-sheet. | Number of observations. | Reference station. | Altitude above sea-level. |
|---|---|---|---|---|---|---|
| | | | | | | *Feet.* |
| 215 | Last Chance and Squaw Queen Creeks, junction of. | California | 47*b* | 2 | Carson City | 5,268.2 |
| 216 | Last Chance and Thompson Creeks, junction of. | do | 47*b* | 2 | do | 5,431.1 |
| 217 | State Line Peak | do | 47*b* | 5 | do | 8,405.2 |
| 218 | Murphy's Ranch, Buffalo Salt Works | do | 47*b* | 1 | Winnemucca | 3,845.0 |
| 219 | Sheep Head | do | 47*b* | 2 | do | 3,913.6 |
| 220 | Bacon's Ranch | do | 47*b* | 2 | do | 4,076.4 |
| 221 | Shumway's Ranch | do | 47*b* | 8 | do | 5,067.0 |
| 222 | McKesick's Ranch | do | 47*b* | 1 | do | 4,469.2 |
| 223 | Smoke Creek Depot | do | 47*b* | 2 | do | 4,163.7 |
| 224 | Winnemucca Lake | Nevada | 47*b* | 2 | American Flat | 3,824.6 |
| 225 | To-ha-kum Peak | do | 47*b* | 3 | do | 8,174.0 |
| 226 | Wood's Ranch, Pyramid Lake | do | 47*b* | 1 | do | 3,861.3 |
| 227 | Dunning's Ranch | do | 47*b* | 2 and 2 | do | 4,571.0 |
| 228 | Willow Ranch | California | 47*b* | 1 and 11 | American Flat and Carson City. | 4,275.3 |
| 229 | Thompson's Peak | do | 47*b* | 6, 12, 12 | Camp 7, American Flat. | 7,752.2 |
| 230 | North End Pyramid Lake | Nevada | 47*b* | 1 | American Flat | 3,847.9 |
| 231 | Greno's Ranch | do | 47*b* | 3 and 2 | do | 4,187.3 |
| 232 | Newton's Ranch, near Honey Lake | do | 47*b* | 2 | do | 4,078.6 |
| 233 | Hot Springs Peak | do | 47*b* | 3 | Winnemucca | 7,692.1 |
| 234 | Schaffer's Station | do | 47*b* | 3 and 2 | do | 4,026.1 |
| 235 | Schaffer's Peak | do | 47*b* | 4 | do | 6,864.5 |
| 236 | Chico | California | 47*c* | D. M. | Red Bluff | 174.9 |
| 237 | Centreville | do | 47*c* | 2 | do | 502.5 |
| 238 | Reservoir in Concord Valley | do | 47*c* | 1 | do | 2,021.9 |
| 239 | Cold Spring Ranch | do | 47*c* | 2 | do | 564.5 |
| 240 | Bidwell's Bar, south fork Feather River | do | 47*c* | 3 | do | 342.1 |
| 241 | Junction House | do | 47*c* | 2 | do | 3,562.2 |
| 242 | Nimshew | do | 47*c* | 3 | do | 2,451.3 |
| 243 | Humbug Park | do | 47*d* | 2 | do | 4,846.6 |
| 244 | Taylor's Ranch | Nevada | 47*d* | 1 | Winnemucca | 4,719.5 |
| 245 | Anderson's Ranch, Fish Spring | do | 47*d* | 2 | do | 4,041.1 |
| 246 | Chapman's Ranch | do | 47*d* | 2 | do | 4,931.6 |
| 247 | Chollar Potosi Mining Company's office | do | 47*d* | D. M. | Salt Lake City | 6,242.3 |
| 248 | Knickerbocker Mine | do | 47*d* | 1 | Chollar Potosi | 5,867.2 |
| 249 | Baltimore Mine | do | 47*d* | 1 | do | 5,729.3 |
| 250 | Globe Consolidated | do | 47*d* | 1 | do | 5,781.0 |
| 251 | Gold Hill Mine | do | 47*d* | 1 | do | 6,373.6 |
| 252 | Superior G. & S. Mine | do | 47*d* | 1 | do | 6,415.3 |
| 253 | West Belcher Mine | do | 47*d* | 1 | do | 6,098.4 |
| 254 | Trojan Mine | do | 47*d* | 1 | do | 6,085.7 |
| 255 | Upper Caledonia Mine | do | 47*d* | 1 | do | 5,986.9 |
| 256 | Europa Mine | do | 47*d* | 1 | do | 5,978.3 |
| 257 | East Justice Hill | do | 47*d* | 3 | do | 5,861.2 |
| 258 | Bacon Mill Point | do | 47*d* | 2 | do | 5,327.2 |
| 259 | Ramsell Mill, near Silver City | do | 47*d* | 1 | do | 5,324.3 |
| 260 | Devil's Gate Toll House, Silver City | do | 47*d* | 1 | do | 5,148.1 |
| 261 | Old Foundery, Silver City | do | 47*d* | 1 | do | 4,940.3 |
| 262 | Gila Mina Post, near Succor Mine | do | 47*d* | 1 | do | 5,451.8 |
| 263 | Vivian Mine | do | 47*d* | 1 | do | 5,414.6 |
| 264 | Darby Mine | do | 47*d* | 1 | do | 4,885.5 |
| 265 | Camp Rock | do | 47*d* | 3 | do | 5,628.2 |
| 266 | American Flat Peak | do | 47*d* | 2 | do | 6,659.0 |
| 267 | Railroad Peak (Black Rock) | do | 47*d* | 1 | do | 5,436.0 |
| 268 | East McClellan Peak | do | 47*d* | 2 | do | 6,180.8 |
| 269 | Rock Island Mine | do | 47*d* | 2 | do | 5,677.5 |
| 270 | Jones's Milk Ranch | do | 47*d* | 2 | do | 5,736.1 |
| 271 | Erie Consolidated Mine | do | 47*d* | 1 | do | 5,268.2 |
| 272 | William Penn Mine | do | 47*d* | 1 | do | 5,235.6 |
| 273 | Buckeye Mine | do | 47*d* | 1 | do | 5,220.8 |
| 274 | Nelson's Station | do | 47*d* | 2 | American Flat | 4,245.0 |
| 275 | Proctor's Ranch, Truckee River | do | 47*d* | 2 | do | 3,963.4 |
| 276 | Pyramid Lake Indian Agency | do | 47*d* | 2 | do | 3,980.0 |
| 277 | Sellers's Ranch, near Reno | do | 47*d* | 3 | do | 4,438.6 |
| 278 | Winters' Ranch | do | 47*d* | 4 | do | 5,145.2 |
| 279 | Wadsworth, Central Pacific Railroad | do | 47*d* | | | 4,094.8 |
| 280 | Home Station | do | 48*d* | 1 | Winnemucca | 4,815.7 |
| 281 | One mile north of Butte Mountain | do | 48*b* | 3 | do | 4,555.2 |
| 282 | Prometheus Peak | do | 48*d* | 6 | do | 8,140.7 |
| 283 | Rooker's Ranch | do | 48*d* | 3 | do | 7,147.9 |

*List of Altitudes*—Continued.

| Number. | Locality. | State or Territory. | Atlas-sheet. | Number of observations. | Reference station. | Altitude above sea-level. |
|---|---|---|---|---|---|---|
| | | | | | | *Feet.* |
| 284 | Geneva Peak | Nevada | 48*d* | 2 | Winnemucca | 10,708.1 |
| 285 | Mouth Underdown Cañon, Reese River | do | 48*d* | 2 and 5 | do | 6,181.1 |
| 286 | Birchim's Peak | do | 48*d* | 3 | do | 10,471.1 |
| 287 | Welche's Ranch | do | 48*d* | 3 | do | 5,771.0 |
| 288 | Emigrant Peak | do | 48*d* | 1 | do | 8,508.5 |
| 289 | Monument at south end of Austin base line. | do | 48*d* | 1 | do | 5,799.2 |
| 290 | Monument at north end of Austin base line. | do | 48*d* | 1 | do | 5,774.4 |
| 291 | Wallace's Ranch | do | 48*d* | 2 | do | 5,786.6 |
| 292 | Rooker's Corral | do | 48*d* | 4 | do | 6,708.5 |
| 293 | Vaughan's Ranch | do | 48*d* | 1 | do | 5,315.9 |
| 294 | Highland Peak | California | 56*b* | | | 10,955.6 |
| 295 | Lillie's Ranch | do | 56*b* | 2 | Sacramento | 3,647.0 |
| 296 | West Point | do | 56*b* | 2 | do | 2,773.7 |
| 297 | Antelope Spring | do | 56*b* | 2 | do | 4,272.5 |
| 298 | Two miles west of Tragedy Springs | do | 56*b* | 2 | do | 7,448.9 |
| 299 | Halfway House | do | 56*b* | 4 | do | 3,358.5 |
| 300 | Shaw's Ranch | do | 56*b* | 2 | do | 6,311.1 |
| 301 | Castle Rock | do | 56*b* | 6 | Sacramento & Winnemucca. | 9,872.4 |
| 302 | Cooper's Ranch | do | 56*b* | 4 | Sacramento | 8,405.9 |
| 303 | Grizzly Peak | do | 56*b* | 2 | Sacramento & Winnemucca. | 10,368.6 |
| 304 | Warm Springs, Sonora Road | do | 56*b* | 2 | Winnemucca | 7,384.5 |
| 305 | Lake near summit of Virginia Creek Trail | do | 56*b* | 2 | Sacramento | 10,089.8 |
| 306 | Grass Lake | do | 56*b* | 1 | do | 8,564.5 |
| 307 | Summit of Big Tree Road | do | 56*b* | 1 | do | 8,157.2 |
| 308 | Big Meadow Ranch | do | 56*b* | 1 | do | 6,838.4 |
| 309 | Fulsom & Hall's Ranch | do | 56*b* | 1 | do | 4,381.8 |
| 310 | Suspension Bridge, Mokelumne River | do | 56*b* | 1 | do | 2,091.5 |
| 311 | Wiley's Station, Amador Road | do | 56*b* | 1 | do | 5,027.4 |
| 312 | Ham's Station, Amador Road | do | 56*b* | 4 | do | 5,438.6 |
| 313 | Mud Spring, Amador Road | do | 56*b* | 1 | do | 5,972.7 |
| 314 | Peddlers' Ranch, Amador Road | do | 56*b* | 1 | do | 6,831.3 |
| 315 | Horsley's Camp | do | 56*b* | 1 | do | 3,859.7 |
| 316 | Myers's Station | do | 56*b* | 1 | do | 3,758.7 |
| 317 | Foster's Station | do | 56*b* | 1 | do | 3,264.9 |
| 318 | Denser's Station | do | 56*b* | 1 | do | 2,921.9 |
| 319 | Volcano | do | 56*b* | 1 | do | 2,075.2 |
| 320 | Foster's Ranch | do | 56*b* | 1 | do | 2,880.9 |
| 321 | Bridge over Middle Fork Mokelumne | do | 56*b* | 1 | do | 2,435.7 |
| 322 | Railroad Flat | do | 56*b* | 1 | do | 2,606.1 |
| 323 | Cabin in South Grove, Calaveras Big Trees | do | 56*b* | 1 | do | 4,820.4 |
| 324 | Columbia P. O | do | 56*b* | 1 | do | 2,156.7 |
| 325 | Bald Mountain | do | 56*b* | 2 | do | 5,829.5 |
| 326 | Lily Creek, Sonora Road | do | 56*b* | 1 | do | 3,970.6 |
| 327 | Mill Creek, Sonora Road | do | 56*b* | 1 | do | 7,075.5 |
| 328 | Niagara Creek, Sonora Road | do | 56*b* | 1 | do | 6,689.8 |
| 329 | Cow Creek Ranch, Sonora Road | do | 56*b* | 1 | do | 5,904.8 |
| 330 | Head of flat, South Fork Herring Creek | do | 56*b* | 1 | do | 7,936.4 |
| 331 | Burst Rock | do | 56*b* | 1 | do | 9,157.4 |
| 332 | Lower Reservoir, ½ mile east of Strawberry. | do | 56*b* | 1 | do | 5,582.4 |
| 333 | Junction of Herring Creek and Stanislaus River. | do | 56*b* | 1 | do | 5,420.9 |
| 334 | Head of Stanislaus | do | 56*b* | 1 | do | 8,856.7 |
| 335 | Small Lake on Relief Trail | do | 56*b* | 1 | Winnemucca | 8,516.8 |
| 336 | Large Lake on Relief Trail | do | 56*b* | 1 | do | 8,182.9 |
| 337 | Round Lake on Relief Trail | do | 56*b* | 1 | do | 7,309.0 |
| 338 | Moran's Ranch | do | 56*b* | 1 | Sacramento | 3,984.2 |
| 339 | Copperopolis, Dutch Henry's Ranch | do | 56*c* | 2 | do | 1,015.3 |
| 340 | Gold Spring Ranch | do | 56*d* | 2 | do | 2,013.7 |
| 341 | Northrups | do | 56*d* | 2 | do | 4,519.1 |
| 342 | Strawberry | do | 56*d* | 3 and 2 | do | 5,237.8 |
| 343 | Dunderberg Peak | do | 56*d* | 8 | do | 12,289.2 |
| 344 | Summit of Virginia Creek Trail | do | 56*d* | 1 | do | 11,045.8 |
| 345 | Lake near Summit Virginia Creek Trail | do | 56*d* | 2 | do | 10,089.8 |
| 346 | Mouth of Lyell Creek | do | 56*d* | 2 | do | 8,574.6 |
| 347 | Lambert's Soda Spring | do | 56*d* | 1 | do | 8,558.1 |
| 348 | Snow's Hotel | do | 56*d* | 2 | do | 5,217.2 |
| 349 | Top of Yosemite Fall | do | 56*d* | 4 | Sacramento and Camp 38. | 6,401.3 |
| 350 | Top of Vernal Fall | do | 56*d* | 4 | do | 4,975.8 |

*List of Altitudes*—Continued.

| Number. | Locality. | State or Territory. | Atlas-sheet. | Number of observations. | Reference station. | Altitude above sea-level. |
|---|---|---|---|---|---|---|
| | | | | | | *Feet.* |
| 351 | Foot of Vernal Fall | California | *56d* | 4 | Sacramento and Camp 38. | 4,632.9 |
| 352 | Upper Fall, Yosemite Falls | do | *56d* | 4 | do | 4,965.1 |
| 353 | Foot of Lower Fall, Yosemite Falls | do | *56d* | 4 | do | 3,985.8 |
| 354 | Top of Nevada Fall, Yosemite Valley | do | *56d* | 4 | do | 5,808.0 |
| 355 | Foot of Nevada Fall, Yosemite Valley | do | *56d* | 4 | do | 5,203.4 |
| 356 | Tamarack Flat | do | *56d* | 2 | Sacramento | 6,233.9 |
| 357 | Crane Flat | do | *56d* | | do | 6,053.6 |
| 358 | Hodgdon's Meadows | do | *56d* | 2 and 1 | do | 4,505.7 |
| 359 | Wade's Meadows | do | *56d* | D. M. and 2. | do | 4,567.0 |
| 360 | Big Tree Tunnel, Oak Flat Road | do | *56d* | 1 | do | 5,793.1 |
| 361 | Hazel Green | do | *56d* | 2 | do | 5,549.5 |
| 362 | Big Meadows | do | *56d* | 7 | do | 4,233.6 |
| 363 | Eleven-mile Station, Mariposa Road | do | *56d* | 2 | do | 5,567.2 |
| 364 | Big Tree Station | do | *56d* | 3 | do | 3,925.3 |
| 365 | Porcupine Flat | do | *56d* | 2 | do | 7,748.5 |
| 366 | Cold Spring | do | *56d* | D. M. and 2. | do | 3,125.8 |
| 367 | Murphy's Cabin, Lake Tenaiya | do | *56d* | | Sacramento and Camp 41. | 7,970.8 |
| 368 | Head of Cascade Creek | do | *56d* | 3 | Camp 44 | 7,717.7 |
| 369 | Pool at foot of Bridal Veil Fall | do | *56d* | 5 | Camp 48 | 4,031.9 |
| 370 | Foot of Virgin's Tears Cliff | do | *56d* | 3 | Sacramento | 5,310.7 |
| 371 | Lower Bridge, Yosemite Valley | do | *56d* | 3 | do | 3,843.1 |
| 372 | Grizzly Giant, Mariposa Grove | do | *56d* | 1 | do | 5,837.8 |
| 373 | Summit Head of North Fork, San Joaquin | do | *56d* | 2 | do | 7,253.3 |
| 374 | Upper Chiquito Meadows | do | *56d* | 2 | do | 6,763.2 |
| 375 | Head of North Fork, San Joaquin | do | *56d* | 2 | do | 7,184.5 |
| 376 | Bridge North Fork, San Joaquin | do | *56d* | 1 | do | 4,385.6 |
| 377 | Mills of Madera Flume and Trading Co. | do | *56d* | 3 | do | 4,499.3 |
| 378 | Mariposa | do | *56d* | 4 and 3 | do | 1,961.8 |
| 379 | Schultz Mountain | do | *56d* | 11 | do | 2,275.2 |
| 380 | Coulterville | do | *56d* | 1 | do | 1,664.9 |
| 381 | Peña Blanca (Haigh's Ranch) | do | *56d* | 3 | do | 1,806.9 |
| 382 | Moccasin Peak | do | *56d* | 3 | do | 3,003.4 |
| 383 | Culbertson's Vineyard | do | *56d* | 2 | do | 980.5 |
| 384 | Sonora (McQuaid's Ranch) | do | *56d* | 2 | do | 1,888.5 |
| 385 | Murphy's | do | *56d* | 1 | do | 2,194.7 |
| 386 | Vallecito Post-Office | do | *56d* | 1 | do | 1,748.4 |
| 387 | Parrott's Ferry | do | *56d* | 1 | do | 834.4 |
| 388 | Brown's Flat | do | *56d* | 1 | do | 1,963.9 |
| 389 | Sonora Post-Office | do | *56d* | 1 | do | 1,815.7 |
| 390 | Baxter's Station, Sonora Road | do | *56d* | 1 | do | 4,114.5 |
| 391 | Bridgeport | | | | | 6,423.5 |
| 392 | Swann's Ranch, East Walker River | California | *57a* | 2 | Winnemucca | 5,041.7 |
| 393 | Cory's Peak | do | *57a* | 5 | do | 11,326.0 |
| 394 | Aurora | do | *57a* | 2 | do | 7,449.2 |
| 395 | French's Peak | Nevada | *57b* | 1 | do | 10,892.7 |
| 396 | Deveringham's Ranch | do | *57b* | 1 | do | 6,496.7 |
| 397 | Poston Peak | do | *57b* | 4 | do | 11,977.7 |
| 398 | Adobe Meadows | California | *57c* | 2 | do | 6,594.4 |
| 399 | McBride's Ranch | do | *57c* | 2 | do | 5,560.6 |
| 400 | McBride's Peak | do | *57c* | 6 | do | 13,442.7 |
| 401 | Fort Lyon | Colorado | *62d* | | | 3,910.2 |
| 402 | Sizer's Ranch | do | *62d* | | | 4,035.5 |
| 403 | Anderson's Ranch | do | *62d* | 3 | Santa Fé | 4,248.5 |
| 404 | Lockwood's Ranch | do | *62d* | 2 and 3 | do | 4,997.3 |
| 405 | Hog Back | do | *62d* | 3 | do | 5,466.8 |
| 406 | Costilla | do | *62d* | 2 | do | 7,792.5 |
| 407 | Alkaline Station | do | *62d* | 3 | Denver | 4,135.8 |
| 408 | Vogle's Ranch | do | *62d* | 4 | Santa Fé | 4,205.3 |
| 409 | Head of Plum Cañon | do | *62d* | 2 | do | 5,754.5 |
| 410 | Lower end of Crane Valley | California | *64b* | 2 | Sacramento | 3,184.8 |
| 411 | Fresno Flat | do | *64b* | D. M. | do | 2,192.4 |
| 412 | Deadwood Peak | do | *64b* | 8 | do | 4,451.3 |
| 413 | Lewis Ranch | do | *64b* | 2 | do | 966.0 |
| 414 | Probasco's Ranch | do | *64b* | D. M. | do | 972.5 |
| 415 | Green Mountain | do | *64b* | 10 | do | 1,351.7 |
| 416 | Fresno, Cal | do | *64b* | D. M. | do | 313.7 |
| 417 | Fowler's Peak | do | *64b* | 9 | do | 1,760.3 |
| 418 | Cole's Ranch | do | *64b* | 8 and 1 | do | 1,221.2 |
| 419 | Base of Hazelton Peak | do | *64b* | 6 | do | 478.6 |
| 420 | Hazelton Peak | do | *64b* | 3 | do | 2,960.5 |

### *List of Altitudes*—Continued.

| Number. | Locality. | State or Territory. | Atlas-sheet. | Number of observations. | Reference station. | Altitude above sea-level. |
|---|---|---|---|---|---|---|
| | | | | | | *Feet.* |
| 421 | Burrows Mountain | California | 64*b* | 11 | Sacramento | 4,267.4 |
| 422 | Behring's Store | do | 64*b* | 3 | do | 4,973.6 |
| 423 | Morrow Mountain | do | 64*b* | 7 | do | 2,065.3 |
| 424 | Eisen Vineyard | do | 64*b* | D. M. | do | 358.0 |
| 425 | Mark Mood Meadows | do | 65*a* | 5 | do | 5,928.1 |
| 426 | Bald Rock | do | 65*a* | 8 | do | 7,825.3 |
| 427 | Lookout Mountain | do | 65*a* | 3 | Camp 21 | 9,669.7 |
| 428 | Dusy's Ranch, on Dinky Creek | do | 65*a* | 3 | Sacramento | 5,542.3 |
| 429 | Ash Springs | do | 65*a* | 2 | do | 1,810.0 |
| 430 | Hyde's Union Saw-Mill | do | 65*a* | 2 | do | 5,297.7 |
| 431 | Bald Mountain (*a*) | do | 65*a* | 6 | do | 8,295.3 |
| 432 | Bald Mountain (*b*) | do | 65*a* | 3 | do | 8,277.8 |
| 433 | Boyd's Ranch | do | 65*a* | 4 | do | 681.8 |
| 434 | Stokes Mountain | do | 65*a* | 3 | do | 2,069.0 |
| 435 | Scodie's Ranch | do | 65*c* | 5 | Los Angeles | 2,715.6 |
| 436 | Canebrake Ranch | do | 65*c* | 3 | do | 3,903.9 |
| 437 | Tilly's Ranch | do | 65*c* | 2 | do | 2.606.6 |
| 438 | Trinchera | do | 69*b* | 2 | Santa Fé | 7,566.7 |
| 439 | Myers' Ferry | | 69*b* | 3 | do | 7,423.7 |
| 440 | Cattle Ranch, Rio Grande | | 69*b* | 2 | do | 7,366.8 |
| 441 | San Cristobal Crossing | New Mexico | 69*b* | 2 | do | 6,575.4 |
| 442 | San Cristobal Crossing, high bank | do | | | do | 7,138.9 |
| 443 | Taos | do | 69*d* | | | 6,949.4 |
| 444 | Ranchos de Taos | do | 69*d* | 1 | Santa Fé | 6,963.3 |
| 445 | United States Mountain Pass No. 1 | do | 69*d* | 1 | do | 8,414.5 |
| 446 | United States Mountain Pass No. 2 | do | 69*d* | 1 | do | 9,251.5 |
| 447 | Head of drain of Pueblo Creek | do | 69*d* | 2 | do | 8,933.9 |
| 448 | Pueblo de Picuris | do | 69*d* | 1 | do | 7,256.7 |
| 449 | Embuda | do | 69*d* | 1 | do | 6.028.9 |
| 450 | La Joya | do | 69*d* | | | 5,712.0 |
| 451 | Plaza del Alcalde | do | 69*d* | | | 5,625.0 |
| 452 | Pojoaque | do | 69*d* | | | 5,760.1 |
| 453 | Pueblo de San Juan | do | 69*d* | 1 | Santa Fé | 5,554.1 |
| 454 | Cuyamungue | do | 69*d* | 1 | do | 5,913.7 |
| 455 | Jesuque Creek, crossing S. F. and T. Road | do | 69*d* | | | 6,668.0 |
| 456 | Costilla Pass | do | 70*a* | 1 | Santa Fé | 10,187.8 |
| 457 | Burbank's Ranch | do | 70*a* | 2 | do | 6,882.2 |
| 458 | Purgatoire Road, 7 miles east of Trinidad | Colorado | 70*a* | 3 | do | 5,843.5 |
| 459 | Purgatoire Road, 4½ miles west of Trinidad | do | 70*a* | 3 | do | 6,198.6 |
| 460 | Cameron's Corner | New Mexico | 70*a* | 3 | do | 7,124.0 |
| 461 | Ponil Pass | do | 70*a* | 1 | do | 9,847.8 |
| 462 | Taos Pass | do | 70*a* | 1 | do | 9,282.2 |
| 463 | Taylor's Ranch | do | 70*a* | 1 | do | 7,226.4 |
| 464 | Fort Union | do | 70*c* | | | 6,744.1 |
| 465 | Dodge's Cut-off | do | 70*c* | 2 | Santa Fé | 6,894.8 |
| 466 | Los Alamos | do | 70*c* | 2 | do | 6,789.0 |
| 467 | Stone Ranch, Canadian Road | do | 70*c* | 2 | do | 5,844.2 |
| 468 | Lake east of Mora | do | 70*c* | 2 | do | 6,185.9 |
| 469 | Caliente | California | 73*a* | | Los Angeles | 1,314.1 |
| 470 | Pampa | do | 73*a* | 1 and 2 | do | 871.0 |
| 471 | Havilah Town | do | 73*a* | 1 | do | 3,149.6 |
| 472 | Palmer's Ranch | do | 73*a* | 2 | do | 2,846.4 |
| 473 | Walker's Pass, summit of | do | 73*a* | 1 | do | 5,322.2 |
| 474 | Birds' Springs | do | 73*a* | 3 | do | 3,949.4 |
| 475 | Welden | do | 73*a* | 2 | do | 2,698.2 |
| 476 | Dahlonega Hot Springs | do | 73*a* | 1 | do | 2,162.3 |
| 477 | Granite Station | do | 73*a* | 2 | do | 1,743.5 |
| 478 | Barker's Ranch | do | 73*a* | 2 | do | 594.3 |
| 479 | Bakersfield | do | 73*a* | 2 | do | 432.0 |
| 480 | Soap Spring | do | 73*a* | 2 | do | 706.4 |
| 481 | Tejon Ranch | do | 73*a* | 3 | do | 1,449.9 |
| 482 | David McKenzie's Ranch | do | 73*a* | 1 | do | 3,715.4 |
| 483 | Twin Lake | do | 73*a* | 2 | do | 5,196.4 |
| 484 | Breckinridge Mountain | do | 73*a* | 3 | do | 5,698.3 |
| 485 | Lievre Ranch | do | 73*c* | 2 | do | 3,756.2 |
| 486 | Hughes Ranch | do | 73*c* | 3 | do | 3,221.9 |
| 487 | Junction of Lievre and Castac Creeks | do | 73*c* | 1 | do | 1,250.9 |
| 488 | Newhall's Ranch | do | 73*c* | 2 | do | 974.1 |
| 489 | San Fernando Tunnel, south mouth | do | 73*c* | 1 | do | 1,428.7 |
| 490 | San Fernando Mission | do | 73*c* | | do | 1,013.0 |
| 491 | Brown's Ranch | do | 73*c* | 2 | do | 1,758.7 |
| 492 | Divide on old stage road between San Fernando Plains and Simi Valley. | do | 73*c* | 1 | do | 1,677.2 |

*List of Altitudes*—Continued.

| Locality. | State or Territory. | Atlas-sheet. | Number of observations. | Reference station. | Altitude above sea-level. |
|---|---|---|---|---|---|
| | | | | | *Feet.* |
| Tapo Ranch | California | *73c* | 2 | Los Angeles | 1, 373. 0 |
| Simi Ranch | do | *73c* | 1 | do | 673. 6 |
| Los Pozos Ranch | do | *73c* | 2 | do | 258. 6 |
| Springville | do | *73c* | 2 | do | 48. 4 |
| Conejo Ranch | do | *73c* | 4 | do | 579. 3 |
| Santa Rosa Valley | do | *73c* | 1 | do | 174. 7 |
| Newberry Park, Camp 39 | do | *73c* | 3 | do | 830. 1 |
| Potraro | do | *73c* | 5 | do | 1, 027. 9 |
| Lion's Head | do | *73c* | 6 | do | 1, 693. 4 |
| Los Encinos Ranch | do | *73c* | 7 and 5 | do | 772. 0 |
| Cahuenga Pass | do | *73c* | 1 | do | 750. 0 |
| Santa Monica | do | *73c* | 4 | do | 15. 4 |
| Lankershin's Ranch | do | *73c* | 2 | do | 568. 3 |
| Sycamore Grove | do | *73c* | 1 | do | 447. 2 |
| General Stoneman's House | do | *73c* | 1 | do | 645. 1 |
| San Gabriel Peak | do | *73c* | ........ | ........ | 6, 232. 0 |
| Azusa | do | *73c* | 2 | Los Angeles | 593. 7 |
| Dalton's Ranch | do | *73c* | 1 | do | 568. 2 |
| San Gabriel Mine | do | *73d* | 2 | do | 1, 702. 5 |
| Pinto Rock | do | *73d* | 2 | do | 3, 903. 4 |
| The Narrows | do | *73d* | 2 | do | 2, 507. 0 |
| Cucamonga Ranch | do | *73d* | 2 | do | 1, 168. 0 |
| San Bernardino | do | *73d* | 2 | do | 950. 1 |
| Stockton's Cabin | do | *73d* | 7 | do | 5, 876. 9 |
| Matthew's Ranch | do | *73d* | 4 | do | 6, 294. 4 |
| Cajon Cañon (Fear's Station) | do | *73d* | 2 | do | 3, 162. 2 |
| Cox Cabin | do | *73d* | 4 | do | 5, 329. 1 |
| Bear Valley Town Hotel | do | *73d* | 2 and 2 | do | 6, 592. 0 |
| Forsee's Ranch | do | *73d* | 4 | do | 3, 587. 1 |
| Tannery | do | *73d* | 2 | do | 4, 399. 9 |
| Saw-mill in Little Bear Valley | do | *73d* | 1 | do | 4, 884. 7 |
| Whisky Johnny's | do | *73d* | 2 | do | 5, 185. 9 |
| Waterman's, R. W | do | *73d* | 1 | do | 1, 908. 4 |
| Colton | do | *73d* | 2 | do | 808. 2 |
| Oak Spring Encinoso | New Mexico | *76d* | 5 | Silver City | 7, 203. 6 |
| High Peak | do | *76d* | 3 | do | 9, 434. 2 |
| Plaza Mangos | do | *76d* | 2 | do | *7, 318. 8 |
| Rito Quemado | do | *76d* | 4 | do | 6, 826. 7 |
| La Pilla | Arizona | *76d* | 2 | do | 5, 849. 8 |
| Mulligan's | do | *76d* | 3 | Fort Bayard | 6, 912. 2 |
| Coyote Spring | do | *76d* | 2 | do | 6, 874. 3 |
| San Francisco on Rio Puerco | New Mexico | *77a* | 3 | Santa Fé | 5, 444. 1 |
| La Bajada | do | *77b* | ........ | ........ | 5, 514. 5 |
| Santo Domingo | do | *77b* | 1 | Santa Fé | 5, 109. 8 |
| Los Pinos | do | *77b* | 1 | do | 4, 674. 8 |
| Peralta | do | *77b* | 1 | do | 4, 661. 1 |
| New Placers | do | *77b* | 3 | do | 6, 666. 9 |
| Placer Peak | do | *77b* | 4 | Camp 22 | 8, 965. 2 |
| Pedernal Water Hole | do | *77b* | D. M. and 3 | Santa Fé | 7, 140. 1 |
| Pedernal Peak | do | *77b* | 6 | Camp 28 | 7, 580. 3 |
| Pedernal Pass | do | *77b* | 1 | Santa Fé | 7, 180. 7 |
| San Marco's Spring | do | *77b* | 2 | do | 6, 055. 8 |
| South Sandia Peak | do | *77b* | 7 | do | 8, 567. 4 |
| Indian Ranch | do | *77b* | 2 | do | 5, 290. 3 |
| Peña Blanca | do | *77b* | D. M | do | 5, 170. 2 |
| Rio Grande at Ford | do | *77b* | 1 | do | 5, 107. 1 |
| Santa Aña | do | *77b* | ...... | do | 5, 292. 0 |
| Divide, eastern rim Rio Puerco | do | *77b* | 1 | do | 5, 934. 1 |
| San Louis Rey | do | *77b* | 2 | do | 5, 152. 0 |
| Mouth of Rio Callo | do | *77b* | 1 | do | 5, 019. 1 |
| Tijeras, ¼ mile above | do | *77b* | 2 | do | 6, 306. 3 |
| Socorro Ford | do | *77c* | 1 | do | 4, 533. 8 |
| Socorro | do | *77c* | 2 and 3 | do | 4, 619. 3 |
| Pueblo Springs | do | *77c* | 2 | do | 6, 398. 1 |
| Corro de Culebra | do | *77c* | 3 | do | 6, 992. 2 |
| Culebra Spring | do | *77c* | 4 | do | 5, 706. 6 |
| Socorro Peak | do | *77c* | 10 | do | 7, 281. 1 |
| Polvadero Peak | do | *77c* | 5 | do | 7, 324. 9 |
| Ojo de la Quinca | do | *77c* | 2 | do | 5, 673. 4 |
| Ladrones Peak | do | *77c* | 4 | Camp 42 | 9, 214. 3 |
| San José | do | *77c* | ........ | Camp 45 | *5, 057. 1 |
| Rio Grande Ford near Socorro | do | *77c* | 1 | Santa Fé | 4, 626. 9 |

*List of Altitudes*—Continued.

| Number. | Locality. | State or Territory. | Atlas-sheet. | Number of observations. | Reference station. | Altitude above sea-level. |
|---|---|---|---|---|---|---|
| | | | | | | *Fee* |
| 565 | Casa Colorada | New Mexico | 77*d* | 1 | Santa Fé | 4,679 |
| 566 | Ojo de la Parida | ...do | 77*d* | 2 | ...do | 4,929 |
| 567 | Cerro Tecolote | ...do | 77*d* | 7 | Camp 72 | 7,253 |
| 568 | Gallinas Spring | ...do | 77*d* | 3 and 7 | Santa Fé and Fort Craig. | 7,672 |
| 569 | West Gallinas Mountain | ...do | 77*d* | 10 | Camp 73 and Santa Fé. | 8,46 |
| 570 | Laguna Gallinas | ...do | 77*d* | D. M. | Fort Craig | 6,393 |
| 571 | Gran Quivira | ...do | 77*d* | D. M. | ...do | 6,406 |
| 572 | Punta de Agua | ...do | 77*d* | 1 | ...do | 6,599 |
| 573 | Lomitas Spring | ...do | 77*d* | 3 | ...do | 5,731 |
| 574 | Chupadero Spring | ...do | 77*d* | 3 | ...do | 6,240 |
| 575 | Chupadero Ranch | ...do | 77*d* | D. M. | ...do | 5,82 |
| 576 | Gallinas Ranch | ...do | 77*d* | 3 | Santa Fé | 6.912 |
| 577 | Berendo Spring | ...do | 77*d* | 1 | ...do | 7,493 |
| 578 | Posos del Pino | ...do | 77*d* | 2, 5, & 3 | ...do | 6,05 |
| 579 | Los Lunas | ...do | 77*d* | ... | ... | 4,803 |
| 580 | Ojo del Oso, Camp 26 | ...do | 77*d* | D. M. | Santa Fé | 7,78 |
| 581 | Mosca Peak | ...do | 77*d* | 16 | Camp 26 | 9,72 |
| 582 | Ojo de Estancia | ...do | 77*d* | ... | Santa Fé | 6,177 |
| 583 | Rattlesnake Hill | ...do | 77*d* | 5 | Camp 30 | 6,616 |
| 584 | La Laguna de Sal | ...do | 77*d* | 1 | Santa Fé | 6,046 |
| 585 | Osha Peak | ...do | 77*d* | 5 | Camp 33 and Santa Fé. | 10,02 |
| 586 | Comanche Cañon Pass | ...do | 77*d* | 1 | Santa Fé | 8,28 |
| 587 | Ojo de la Casa | ...do | 77*d* | 2 | ...do | 6,242 |
| 588 | Belen | ...do | 77*d* | ... | ... | 4,812 |
| 589 | Picacho de Sabinal | ...do | 77*d* | ... | ... | 4,675 |
| 590 | Los Lunas Ford | ...do | 77*d* | 1 | Santa Fé | 4,93 |
| 591 | Manzano Peak | ...do | 77*d* | 1 | ...do | 10,086 |
| 592 | Tomasceños Water Holes | ...do | 77*d* | 1 | ...do | 5,501 |
| 593 | Ojo del Cibolo | ...do | 77*d* | 2 | ...do | 5,640 |
| 594 | Cibolo Hill | ...do | 77*d* | 1 | ...do | 6,472 |
| 595 | Tanques de Cañoncito | ...do | 77*d* | 2 | ...do | 5,083 |
| 596 | Constancia | ...do | 77*d* | 1 | ...do | 4,711 |
| 597 | Ojo de las Cañas | ...do | 77*d* | 2 | ...do | 5,130 |
| 598 | Mesteñito Ranch | ...do | 77*d* | 3 | ...do | 6,265 |
| 599 | Pyramid Hill | ...do | 77*d* | 4 | Camp 58 and Santa Fé. | 6,628 |
| 600 | Upper Abo Pass | ...do | 77*d* | 1 | Santa Fé | 6,431 |
| 601 | Ojo Chameleon | ...do | 77*d* | 4 | Camp 10 | 6,401 |
| 602 | Alamillo | ...do | 77*d* | 2 | Santa Fé | 4,600 |
| 603 | Algodones | ...do | 77*d* | D. M. | Georgetown and Santa Fé. | 5,10 |
| 604 | Sandia | ...do | 77*d* | 1 | ...do | 4,932 |
| 605 | Alameda | ...do | 77*d* | 1 | ...do | 4,905 |
| 606 | Mouth of Rincon Colorado | ...do | 78*a* | 3 | Santa Fé | 5,357 |
| 607 | Head of Cañon Largo | ...do | 78*a* | 4 | ...do | 6,84 |
| 608 | South end of Mesa Chupaines | ...do | 78*a* | 5 | ...do | 6,59 |
| 609 | Head of Cañon de Agua | ...do | 78*a* | 1 | ...do | 6,853 |
| 610 | Mouth of Conchas Cañon, west bank of Arroyo. | ...do | 78*a* | 3 | ...do | 5,162 |
| 611 | Church at Riverside | California | 80*b* | 1 | Los Angeles | 891 |
| 612 | Santa Aña Hotel | ...do | 80*b* | 2 | ...do | 141 |
| 613 | Camp Apache | Arizona | 83*b* | ... | Santa Fé | 5,000 |
| 614 | Cienega Amarilla | New Mexico | 83*b* | 2 | Fort Bayard & Silver City. | 7,178 |
| 615 | Carrizo Spring | ...do | 83*b* | 2 | Fort Bayard | 7,827 |
| 616 | Gallo Spring | ...do | 83*b* | 2 | ...do | 7,586 |
| 617 | Patterson's Ranch | ...do | 83*b* | 4 and 2 | Fort Bayard & Silver City. | 6,719 |
| 618 | Paria's Spring | ...do | 83*b* | 2 | Silver City | 6,895 |
| 619 | Becker's Store, Springerville | Arizona | 83*b* | 2 | ...do | 6,758 |
| 620 | San Francisco | New Mexico | 83*b* | 2 | ...do | 5,68 |
| 621 | Torreon Springs | ...do | 84*a* | D. M. | Santa Fé | 5,979 |
| 622 | Cuchilla Negra | ...do | 84*a* | 1 | ...do | 4,568 |
| 623 | Ferry to Fort McRae | ...do | 84*a* | 1 | ...do | 4,093 |
| 624 | Fort McRae | ...do | 84*a* | ... | Silver City and Santa Fé, | 4,89 |
| 625 | Eight-tenths mile above Fort McRae | ...do | 84*a* | 3 | Santa Fé | 4,469 |
| 626 | Alamocita | ...do | 84*a* | 1 | ...do | 4,255 |
| 627 | Rio Grande, 2½ miles above Alamocita | ...do | 84*a* | 3 | ...do | 4,233 |
| 628 | Chupadero Spring | ...do | 84*a* | 5 | ...do | 4,892 |

*List of Altitudes*—Continued.

| Locality. | State or Territory. | Atlas-sheet. | Number of observations. | Reference station. | Altitude above sea-level. |
|---|---|---|---|---|---|
| | | | | | *Feet.* |
| Fray Cristobal | New Mexico | 84*a* | 9 | Camp 42 | 6,646.2 |
| Paraje | do | 84*a* | 1 | Santa Fé | 4,319.2 |
| Paraje Ferry | do | 84*a* | D. M. | do | 4,352.5 |
| San Mateo Peak | do | 84*a* | 8 | do | 10,208.6 |
| La Monica Springs | do | 84*a* | | Silver City and Santa Fé. | 7,601.9 |
| Magdelena Peak | do | 84*a* | 9 | Camp 40 | 10,798.0 |
| Garcia Peak | do | 84*a* | 8 | do | 9,919.8 |
| San Mateo Divide | do | 84*a* | 1 | Silver City | 8,960.1 |
| Ojo Caliente | do | 84*a* | 4 and 2 | do | 6,081.0 |
| Shaw's Ranch | do | 84*a* | 4 | do | 7,255.7 |
| Old Camp Sherman | do | 84*a* | D. M. | do | 6,926.6 |
| Alamo Station | do | 84*a* | 8 | do | 6,593.0 |
| Camp Vincent | do | 84*a* | 6 | do | 6,188.1 |
| McKnight's Ranch | do | 84*a* | 2 | do | 6,237.2 |
| Continental Divide, head of Cuchillo Negro. | do | 84*a* | 1 | do | 7,698.2 |
| Head of Middle Fork Cuchillo Negro | do | 84*a* | 2 | do | 7,628.3 |
| Luera Spring | do | 84*a* | D. M. | do | 7,585.2 |
| Continental Divide, on road from Ojo Caliente to Shaw's Ranch. | do | 84*a* | 1 | do | 7,921.5 |
| Fort Craig | do | 84*a* | D. M. | Santa Fé | 4,447.5 |
| Toussaint's Ranch | do | 84*b* | 3 | do | 4,634.0 |
| Dripping Springs | do | 84*b* | D. M. | Fort Craig | 5,623.4 |
| Salinas Peak | do | 84*b* | 9 | Dripp'g Spring | 9,039.5 |
| Mound Spring | do | 84*b* | 4 | Fort Craig | 4,335.7 |
| Jaraloso Spring | do | 84*b* | | do | 4,783.1 |
| Nogal Peak | do | 84*b* | 5 | Camp 50 | 9,983.0 |
| Fort Stanton | do | 84*b* | | | 6,151.5 |
| Dowlin's Mill | do | 84*b* | | | 6,491.0 |
| Head of Carrizo Creek | do | 84*b* | 2 | Fort Craig | 8,831.3 |
| Sierra Blanca Peak | do | 84*b* | 9 | Fort Craig and Santa Fé. | 11,892.3 |
| Tres Cerros Spring | do | 84*b* | 1 | Fort Craig | 6,127.7 |
| East Carrizo Cone | do | 84*b* | 9 | do | 7,975.7 |
| Murphy's Ranch, Carrizozo Spring | do | 84*b* | | | 5,300.0 |
| North end of Mal-Pais | do | 84*b* | 6 | Fort Craig | 5,360.4 |
| White Oak Spring | do | 84*b* | 3 | do | 6,617.7 |
| Taylor's Ranch, Jicarilla Mountains | do | 84*b* | 6 | do | 6,988.3 |
| Winter's Ranch, Jicarilla Mountains | do | 84*b* | | | 6,582.4 |
| West Jicarilla Cone | do | 84*b* | 5 | Camp 71 | 7,726.7 |
| Camp Llano Spring | do | 84*b* | 4 | Fort Craig | 5,348.2 |
| Cerro Colorado | do | 84*b* | 9 | Camp 81 | 5,653.7 |
| San Pedro | do | 84*b* | 1 | Fort Craig | 4,488.4 |
| San Marcial | do | 84*b* | 1 | do | 4,385.1 |
| Oscura Water Holes | do | 84*b* | D. M. | do | 5,461.3 |
| South Oscura Mountain | do | 84*b* | 7 | Camp 93 | 8,732.3 |
| Mal-Pais Spring | do | 84*b* | 4 | Fort Craig | 4,105.6 |
| Ojo Milagro | do | 84*b* | 3 | do | 5,172.5 |
| Puertocito | do | 84*b* | 5 | | 6,428.3 |
| Six miles above Mal-Pais Spring | do | 84*b* | 3 | Fort Bliss | 4,115.0 |
| Fort Selden | do | 84*c* | | | 3,900.0 |
| Point of Rocks | do | 84*c* | D. M. | Silver City | 4,268.3 |
| Aleman or Martin's Ranch | do | 84*c* | 5 | do | 4,594.3 |
| Left bank Rio Grande, opposite Polomas | do | 84*c* | D. M. | do | 4,120.8 |
| Rio Grande, 39 miles from Polomas | do | 84*c* | 2 | Fort Bayard | 3,955.5 |
| Fairbell Hill | do | 84*c* | 2 | Silver City | 6,588.9 |
| Hillsboro' | do | 84*c* | | do | 5,223.8 |
| Upper Ford of Black River | do | 84*c* | 3 | do | 6,702.3 |
| Fest Ranch | do | 84*c* | D. M. | Fort Bliss | 4,183.5 |
| Entrance to Nell's Pass | do | 84*c* | 1 | Silver City | 6,683.3 |
| Polomas | do | 84*c* | 4 | do | 4,160.4 |
| Brent's Ranch | do | 84*c* | 1 | do | 4,021.4 |
| Shaw's Ranch, Animas River | do | 84*c* | 4 | do | 4,691.9 |
| Animas Peak | do | 84*c* | 2 | do | 6,106.1 |
| Divide at head of Perces River | do | 84*c* | 1 | Camp 48 | 8,264.2 |
| Head of Sierra Blanca Creek | do | 84*c* | 4 | Fort Bayard | 6,307.1 |
| Divide at head of Chicken Creek | do | 84*c* | 1 | do | 7,445.1 |
| McEver's Ranch | do | 84*c* | 2 | do | 5,086.2 |
| Colorado Plaza, Rio Grande | do | 84*c* | 2 | do | 4,007.8 |
| Picacho Peak | do | 84*c* | 1 | do | 4,824.5 |
| Slocum's Ranch | do | 84*c* | 2 | do | 4,519.1 |
| Magdalena Pass | do | 84*c* | 1 | do | 4,754.6 |

*List of Altitudes*—Continued.

| Number. | Locality. | State or Territory. | Atlas-sheet. | Number of observations. | Reference station. | Altitude above sea-level. |
|---|---|---|---|---|---|---|
| | | | | | | *Feet* |
| 698 | Mason's Ranch | New Mexico | 84*c* | 2 | Fort Bayard | 4,771 |
| 699 | Cañada Ranch | do | 84*c* | 3 | Silver City | 5,088 |
| 700 | Fort Cummings | do | 84*c* | | | 4,840 |
| 701 | Macho or Mule Springs | do | 84*c* | | | 5,261 |
| 702 | Mule Springs, 5 miles west of Macho Springs. | do | 84*c* | 2 | Silver City | 5,652 |
| 703 | Hurricane Rock | do | 84*c* | 2 | do | 6,478 |
| 704 | Rio Mimbres Ford | do | 84*c* | 1 | do | 5,028 |
| 705 | Warm Springs | do | 84*c* | | Santa Fé and Silver City. | 5,008 |
| 706 | Mimbres Settlement | do | 84*c* | 1 | Silver City | 5,007. |
| 707 | Crittenden's Ranch | do | 84*c* | 1 | do | 5,004. |
| 708 | Divide, between Warm Springs and Mimbres Settlement. | do | 84*c* | 1 | do | 5,273. |
| 709 | Hot Springs | do | 84*c* | 1 | do | 5,065. |
| 710 | Fort Bayard | do | 84*c* | | | 6,068. |
| 711 | Lone Mountain | do | 84*c* | 3 | Silver City | 5,985. |
| 712 | Apache Tejo | do | 84*c* | | | 5,478. |
| 713 | Cow Spring | do | 84*c* | | | 5,000. |
| 714 | Hot Springs (13 miles from Magruder's) | do | 84*c* | 1 | Santa Fé | 5,781. |
| 715 | Mimbre's Forks | do | 84*c* | 4 | do | 7,562. |
| 716 | Head of Black River | do | 84*c* | 4 | do | 7,456. |
| 717 | Diablo Knoll | do | 84*c* | 1 | do | 7,616. |
| 718 | Pinos Altos | do | 84*c* | 8 | do | 6,844. |
| 719 | Pinos Altos Peak | do | 84*c* | 3 | do | 8,127. |
| 720 | Black Peak | do | 84*c* | 3 | do | 8,909. |
| 721 | Hanover Peak | do | 84*c* | 3 | do | 7,396. |
| 722 | Cook's Peak | do | 84*c* | 3 | Silver City | 8,329. |
| 723 | Santa Rita Copper Mines | do | 84*c* | 2 | Santa Fé | 6,161. |
| 724 | Georgetown | do | 84*c* | 2 | do | 6,455. |
| 725 | Hendrick's Peak | do | 84*c* | 3 | do | 7,573. |
| 726 | South end of Bayard Base, Station B | do | 84*c* | 3 | Silver City | 5,514. |
| 727 | Cow Spring, Pyramid F | do | 84*c* | 3 | do | 5,768. |
| 728 | Bluff Hill, Station D | do | 84*c* | 3 | do | 7,217. |
| 729 | Tularosa | do | 84*d* | 3<br>D. M. | Silver City and Fort Craig. | 4,357. |
| 730 | San Nicolas Spring | do | 84*d* | 3 | Fort Bliss and Silver City. | 4,218. |
| 731 | Shedd's Ranch, San Augustin | do | 84*d* | D. M. | do | 4,378. |
| 732 | San Augustin Pass | do | 84*d* | 1 | Fort Bliss | 5,653. |
| 733 | ½ mile south of White Water Spring | do | 84*d* | 3 | Silver City | 3,888. |
| 734 | Indian Agency, near Blazer's Mill | do | 84*d* | 3 | | 6,448. |
| 735 | Elk Spring | do | 84*d* | D. M. | Santa Fé | 7,414. |
| 736 | Silver Springs | do | 84*d* | D. M. | do | 7,638. |
| 737 | Head of Peñasco Creek | do | 84*d* | 5 | do | 7,159. |
| 738 | Ford of Peñasco Creek at Corral | do | 84*d* | D. M. | do | 6,692. |
| 739 | Spring, 2½ miles north of Elk Spring | do | 84*d* | 2 | do | 7,503. |
| 740 | Roblado Peak | do | 84*d* | 2 | Camp 53 | 5,574. |
| 741 | Las Cruces | do | 84*d* | D. M. and 4 | Fort Bayard | 3,808. |
| 742 | Mesilla Crossing, Rio Grande | do | 84*d* | 1 | do | 3,754. |
| 743 | Capitan Peak | do | 85*a* | 8 | Fort Craig | 10,022. |
| 744 | Capitan Pass | do | 85*a* | 1 | Santa Fé | 7,398. |
| 745 | Hacheta Peak | do | 89*b* | 5 | do | 8,352. |
| 746 | La Lacha Spring | do | 89*b* | 4 | do | 4,755. |
| 747 | Black Rock Tank | do | 90*a* | 2 | do | 4,179. |
| 748 | Kettle Spring | do | 90*a* | 2 | do | 4,539. |
| 749 | South Florida Peak | do | 90*a* | 3 | do | 7,261. |
| 750 | Las Tenejas | do | 90*a* | 2 | do | 4,748. |
| 751 | Nigger Head Spring | do | 90*a* | 2 | do | 4,861. |
| 752 | Carrizillo Spring | do | 90*a* | 2 | do | 4,457. |
| 753 | Florida Peak | do | 90*a* | 3 | do | 7,295. |
| 754 | Jackson Ranch | do | 90*c* | 4 | Fort Bayard | 3,787. |
| 755 | Cottonwood Springs | do | 90*c* | 4 | Silver City | 4,773. |
| 756 | North Franklin Peak | do | 90*c* | 2 | do | 7,060. |

The altitudes of points marked thus (*) are from aneroid determinations; all others from the cister barometer.

### *Table of Altitudes of Points of Interest in and about the Yosemite Valley.**

#### WATERFALLS.

| Name. | Height above valley. | Height of fall. | Remarks. |
|---|---|---|---|
| | *Feet.* | *Feet.* | |
| Yosemite Falls, top | 2,550 | | Measured by theodolite and barometer. |
| Pool, foot of Upper Fall | 1,114 | | Measured by barometer. |
| Top Lower Fall | 488 | | Measured by theodolite. |
| Upper Fall | | 1,436 | |
| Second Fall | | 626 | |
| Third Fall | | 488 | |
| Nevada Fall, top | 1,957 | | Measured by barometer. |
| Pool at foot of fall | 1,352 | | Do. |
| Nevada Fall | | 605 | Do. |
| Vernal Fall, top | 1,125 | | |
| Vernal Fall, base | 782 | | Do. |
| Vernal Fall | | 343 | Do. |

These altitudes are referred to floor of upper bridge, 3,851 feet above sea by barometer.

* This list is compiled for immediate use from such observations as have been worked up. Additions will be made as soon as the computations are completed.

#### POINTS IN THE VICINITY OF THE VALLEY.

| Name. | Height above valley. | Height above sea. | Remarks. |
|---|---|---|---|
| | *Feet.* | *Feet.* | |
| Union Point | 2,356.0 | 6,207.0 | Measured by theodolite. |
| Union Point Finger | 2,340.0 | 6,191.0 | Do. |
| Sentinel Rock | 3,069.0 | 6,920.0 | Do. |
| Glacier Point (railing) | 3,257.0 | 7,108.0 | Do. |
| Yosemite Falls flag | 2,593.0 | 6,444.0 | Do. |
| Eagle Point | 3,818.0 | 7,669.0 | Do. |
| Cloud's Rest | 5,921.5 | 9,772.5 | By barometer. |
| South Dome (lip) | 4,953.0 | 8,804.0 | Measured by theodolite. |
| Sentinel Dome | 4,160.0 | 8,011.0 | Do. |
| North Dome | 3,633.0 | 7,484.0 | Do. |
| Columbia Rock | 1,154.0 | 5,005.0 | Do. |
| Cathedral Rock (higher) | 2,678.0 | 6,529.0 | Do. |
| Cathedral Rock (lower) | 2,579.0 | 6,430.0 | Do. |
| Starr King | 5,171.0 | 9,022.0 | Do. |

#### PROMINENT PEAKS.

| Name. | Height above sea. | Measured by— | Remarks. |
|---|---|---|---|
| | *Feet.* | | |
| Clark | 11,295 | Barometer | Also called Gothic Peak and the Obelisk. |
| Connees | 12,518 | do | |
| Echo | 11,231 | do | Near Cathedral Peak. |
| Hoffmann | 10,872 | do | |
| Merced | 11,442 | do | Highest of the Mount Clark Group. |
| Lyell | 13,191 | do | |
| Devil's | 6,910 | do | |
| Wade's | 7,153 | do | |
| Chiquito | 8,136 | do | |

## TOPOGRAPHICAL MAPS AND PROGRESS-SHEET.

Seven regular topographical atlas-sheets, on a scale of 1 inch to 4 miles, with land-classification areas added, will accompany the extra copies asked for of this report, but are not forwarded for insertion in the full report of the Chief of Engineers. These are numbered 32 D, 47 B + 47 D, 61 D, 73 A, 78 A, 84 B, and lie in the political divisions of California, Nevada, and New Mexico. The large amount of collected topographical data remaining unpublished (*i. e.*, nearly forty atlas-sheets), would admit of the preparation of a much larger number within a year, but the office has not had available draughtsmen.

The progress-map herewith submitted shows the extension of the rectangle scheme eastward to the Mississippi River, thus giving 123 divisions instead of 95, as heretofore. The divisions are of convenient-sized areas, and can be used as the basis of a further subdivision, and, since the special projection practically limits distortion to a minimum and admits of the conjoining of the sheets, it is respectfully suggested that all maps hereafter made of this region by the Engineer Department might be constructed upon this projection to secure uniformity. The altitudes of a number of barometer reference-stations have been added, and the map brought down to date as nearly as the limited time for its revision has permitted.

## LAND CLASSIFICATION AREAS AND MAPS.

Observations upon the varied native resources of the soil and underlying rock were undertaken as early as 1872, having been required by the instructions of that year. The systematic classification of the land in conjoining areas was only begun, however, in 1874, and has since continued with increasing detail year by year without interruption. Without appreciable additional time or cost, the measurements, examinations, and notes required by which to demark the boundaries between tracts valuable, for instance, for grazing or as timber, can be made by the assistants engaged in the triangulation and topographical observations required in the general topographical survey of a given region, and thus the quality of the land becomes known before it is parcelled out into legal subdivisions. It cannot be expected, nor is it claimed, that the results are more than approximate, as no rigid rule can be applied, and the judgment of the individual must often decide where, for instance, should be noted the gradation from the grazing to the timber line, along sloping foot-hills, where the former advances into timbered areas. The grazing may be either good or bad, it being impracticable in most cases to note with accuracy the variations. At most, the percentages given are but approximations.

The agricultural land reported in the accompanying tables is confined to the area that can be cultivated by irrigation, it having been ascertained that a sufficient quantity of water is available, and as the estimates have been kept *below* a minimum, it is fair to presume that at some future period the amount actually cultivated may prove to be in excess of amounts stated, resulting from the small local increase due to irrigation itself, not taking into account the periodic changes in rainfall. Soil susceptible of cultivation by means of irrigation, and for which water cannot apparently be had, has been thrown into the division of arid and barren. On account of the expense of publishing in colors, only four divisions have been shown, *i. e.*, (1) arable or agricultural with irrigation; (2) arid and barren; (3) timber; (4) pasturage or grazing.

The number of divisions can be largely expanded, however, and of late have covered the cases given below that serve as a description of all classes now known to the law in its disposition of the public lands, *i. e.:*

1. Arable or agricultural, { without irrigation.
   with irrigation (sufficient water being available), or drainage.
2. Timber, { (1) large / (2) small } with prevailing species, as live-oak, cedar, &c.

3. Pasturage or grazing, $\left\{\begin{array}{l}(1)\text{ good}\\(2)\text{ bad}\end{array}\right\}$ with species and quality of grasses.
4. Arid or barren, including "desert-lands."
5. Swamp, tide, and overflowed.
6. Location of the precious and economic minerals, such as—

1. Gold, in place or placer.
2. Silver.
3. Cinnabar.
4. Copper.
5. Lead.
6. Iron.
7. Coal.
8. Tin or nickel.
9. Antimony and arsenic.
10. Sulphur.
11. Sodium, chloride and carbonate of.
12. Alum and borates.
13. Peats, marls, and clays.
14. Asphaltum, petroleum.

The following table exhibits the approximate percentages found in areas examined that exceed 125,000 square miles. More values will be given as fast as they can be prepared. While the percentage of "arable" appears small, still the area actually "arid and barren," and worthless for agricultural purposes in but one case reaches 53.18 per cent.; while it is to be remarked that quite a number of these atlas sheets embrace some of the most completely desert portions of the United States:

*Table of Land Classification.*

| States or Territories. | Atlas sheet number, as per progress-map herewith. | Number of square miles examined and classified. | Land classification. | | | | | | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Arable or agricultural, with irrigation. | Approximate percentage of area. | Pasturage or grazing. | Approximate percentage of area. | Timber. | Approximate percentage of area. | Arid or barren. | Approximate percentage of area. | |
| | | *Total sq. miles.* | *Sq. miles.* | *Pr. cent.* | *Sq. miles.* | *Pr. cent.* | *Sq. miles.* | *Pr. cent.* | *Sq. miles.* | *Pr. cent.* | |
| Idaho | 32 C | 4,022.58 | 20.38 | 0.50 | 2,247.85 | 55.90 | 230.05 | 5.70 | 1,524.30 | 37.90 | To be published. |
| Idaho, Wyoming | 32 D | 4,022.58 | 30.00 | 0.73 | 2,818.10 | 70.08 | 1,000.36 | 24.87 | 120.00 | 2.98 | 1.34 per cent. of lakes, ponds, and marshes, or 54.12 square miles. To accompany extra copies Annual Report 1879. |
| California, Nevada | 38 D | 4,127.18 | 111.60 | 2.80 | 3,115.10 | 75.55 | 430.57 | 10.15 | 401.28 | 9.80 | 1.70 per cent. of lakes, ponds, and marshes, or 68.63 square miles. To be published. |
| Idaho, Utah | 41 A | 4,075.29 | 58.50 | 1.45 | 2,938.65 | 72.13 | 441.24 | 10.82 | 363.60 | 8.90 | 6.70 per cent. of lakes, ponds, and marshes, or 273.30 square miles. To be published. |
| Idaho, Utah, Wyoming | 41 B | 4,075.29 | 971.40 | 23.83 | 1,883.45 | 46.21 | 867.80 | 21.30 | 132.10 | 3.25 | 5.41 per cent. of lakes, ponds, and marshes, or 220.54 square miles. Published with extra copies Annual Report 1878. |
| California | 47 A | 4,178.42 | 229.35 | 5.50 | 1,091.22 | 26.20 | 2,636.10 | 63.00 | 146.15 | 3.50 | 1.80 per cent. of lakes, ponds, and marshes, or 75.60 square miles. To be published. |
| California, Nevada | 47 B | 4,178.42 | 120.68 | 2.89 | 526.10 | 12.59 | 625.25 | 14.96 | 2,227.94 | 53.32 | 16.24 per cent. of lakes, ponds, and marshes, or 678.45 square miles. To accompany extra copies Annual Report 1879. |
| Do | 47 D | 4,228.56 | ........ | ........ | ........ | ........ | ........ | ........ | ........ | ........ | —— per cent, of lakes, ponds, and marshes, or —— square miles. To accompany extra copies Annual Report 1879. |
| Colorado | 53 C (P) | 1,590.86 | 135.34 | 8.50 | 906.44 | 57.00 | 477.58 | 30.00 | 71.50 | 4.50 | Published as topographical sheet only. |
| Do | 61 A | 4,278.00 | 233.00 | 5.45 | 2,217.00 | 51.82 | 1,493.00 | 34.90 | 335.00 | 7.83 | Published with extra copies Annual Report 1878. |
| Do | 61 B | 4,278.00 | 403.00 | 9.41 | 757.00 | 17.70 | 2,223.00 | 51.98 | 895.00 | 20.91 | Published with extra copies Annual Report 1877. |
| Do | 61 C | 4,326.29 | 59.67 | 1.37 | 410.21 | 9.48 | 2,670.31 | 61.73 | 1,186.10 | 27.42 | Published with extra copies Annual Report 1878. |
| Do | 61 D | 4,326.29 | 443.29 | 10.24 | 1,470.00 | 34.00 | 1,232.00 | 28.46 | 1,181.00 | 27.30 | To be published. |
| Do | 62 A | 4,278.00 | 291.00 | 6.80 | 2,970.00 | 69.42 | 773.00 | 18.07 | 244.00 | 5.71 | Published with extra copies Annual Report 1878. |
| Do | 62 C | 4,326.29 | 197.00 | 4.62 | 2,773.20 | 64.11 | 1,151.09 | 26.42 | 205.00 | 4.85 | Do. |
| California | 65 D | 4,420.20 | 67.00 | 1.50 | 2,132.00 | 48.20 | 430.00 | 9.70 | 1,791.20 | 40.60 | Published with extra copies Annual Report 1877. |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Colorado, New Mexico | 69 (P) | 16, 059. 52 | 930. 68 | 5. 80 | 8, 334. 26 | 51. 90 | 5, 836. 90 | 36. 35 | 957. 68 | 5. 95 | 69 B. Published with extra copies Annual Report 1877.<br>69 D. Published with extra copies Annual Report 1878.<br>69 (P). To be published. |
| Colorado, New Mexico | 70 A | 4, 373. 74 | 168. 00 | 3. 88 | 1, 412. 00 | 32. 25 | 2, 536. 74 | 58. 00 | 257. 00 | 5. 87 | Published with extra copies Annual Report 1877. |
| New Mexico | 70 C | 4, 420. 20 | 155. 00 | 3. 51 | 2, 797. 20 | 63. 28 | 1, 328. 00 | 30. 05 | 140. 00 | 3. 16 | Do. |
| Arizona | 75 | 17, 952. 24 | 796. 24 | 4. 40 | 7, 154. 00 | 39. 90 | 2, 614. 00 | 14. 60 | 7, 388. 00 | 41. 10 | Published as topographical sheet only. |
| New Mexico | 77 B | 4, 465. 85 | 193. 00 | 4. 32 | 2, 537. 85 | 56, 84 | 1, 015, 00 | 22. 73 | 720. 00 | 16. 11 | Published with extra copies Annual Report 1877. |
| Do | 77 D | 4, 510. 27 | 88. 04 | 1. 92 | 3, 300. 43 | 73. 18 | 933. 34 | 20. 70 | 188. 46 | 4. 20 | Published with extra copies Annual Report 1878. |
| Do | 78 A | 4, 465. 85 | 84, 08 | 1. 88 | 3, 430. 22 | 76. 82 | 804. 52 | 18. 01 | 147. 08 | 3. 29 | Published with extra copies Annual Report 1879. |
| Arizona, New Mexico | 83 (P) | 13, 573. 47 | 228. 09 | 1. 65 | 5, 850. 17 | 43. 12 | 4, 441. 61 | 32. 80 | 3, 053. 60 | 22. 43 | Published as topographical sheet only. |
| New Mexico | 84 B | 4, 554. 13 | 32. 00 | 0. 70 | 3, 480. 27 | 76. 40 | 871. 60 | 19. 20 | 170. 26 | 3. 70 | To accompany extra copies Annual Report 1879. |

NOTE.—(P) after the atlas-sheet number signifies that only a portion of the sheet has been classified.

Adverting to the mooted question of a change in the system, or rather of the size and shape of the tracts of land to be parcelled out to the settler, it may be said that, should a classification resulting from observations made by topographical engineers engaged in a general survey be developed to embrace the whole public domain, an intelligent idea could then be formed of the necessity therefor; and, *ad interim*, the rights of the settler now occupying in advance of the land-survey, as well as those electing meanwhile to homestead upon the public domain, would be preserved under existing laws, the government thereby reserving all its rights as trustee; and, indeed, no change should be made in the present subdivision of the townships until the government is possessed of full information upon which to base a new plan, such as could alone result from a complete and exhaustive classification of the entire area remaining unparcelled. The number of land-classification sheets published to date is twenty-one, and twelve others are in various stages of completion.

## ROUTES OF COMMUNICATION.

Lists of distances over the most important routes of the regions visited by the several main parties, prepared under the supervision of each chief of party, are herewith given.

The special report, giving lists of geographical positions, altitudes, distances, &c., being again delayed, will contain a combined exhibit of all prominent route-distances obtained up to and including 1879.

### LIST OF DISTANCES BETWEEN PROMINENT POINTS MEANDERED BY PARTY NO. 2, COLORADO SECTION, 1878.

Fort Bliss, Tex., to Fort Craig, N. Mex.
Fort Stanton, N. Mex., to Fort Bliss, Tex.

*From Fort Bliss, Tex., to Fort Craig, N. Mex.—Atlas-sheets Nos.* 90 *and* 84.

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Fort Bliss. | From Fort Craig. | | |
| Fort Bliss | ........ | ........ | 147. 86 | 3, 622. 9 | Three-company post. |
| Jackson's Ranch (or Cottonwoods) | 25. 24 | 25. 24 | 122. 62 | 3, 737. 8 | Government agency; wood, water, and grazing. |
| Las Cruces | 21. 11 | 46. 35 | 101. 51 | 3, 808. 5 | Town; government agency. |
| Doña Ana | 6. 05 | 52. 40 | 95. 46 | .......... | Town. |
| Fort Selden | 9. 39 | 61. 79 | 86. 07 | 3, 900. 0 | Wood, water, and grazing. |
| Point of Rocks | 19. 87 | 81. 66 | 66. 20 | 4, 268. 3 | Stage-station; water and grazing; fuel scarce. |
| Aleman | 17. 53 | 99. 19 | 48. 67 | 4, 594. 3 | Martin's Well; government agency; good grazing. |
| Toussaint's Ranch | 21. 08 | 120. 27 | 27. 59 | 4, 634. 0 | Government agency; water in tanks; good grazing. |
| Paraje | 18. 52 | 138. 79 | 9. 07 | 4, 319. 2 | Mexican town; government agency; no grazing. |
| Ferry | 3. 37 | 142. 16 | 5. 70 | .......... | Crossing of the Rio Grande. |
| Fort Craig | 5. 70 | 147. 86 | ........ | 4, 447. 5 | Good grazing; water plenty. |

From Aleman to Fort McRae, 16.93 miles.
From Fort McRae to Touissaints, 12.36 miles.
Road follows east bank of Rio Grande and crosses river at ferry. Fort Craig is on west bank

*From Fort Stanton, N. Mex., to Fort Bliss, Tex.—Atlas-sheet No.* 84.

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Fort Stanton. | From Fort Bliss. | | |
| Fort Stanton | ........ | ........ | 160. 67 | 6, 151. 5 | Four-company post. |
| Dowlin's Mill | 20. 88 | 20. 88 | 139. 79 | 6, 491. 0 | Government agency; good grazing. |
| Blazar's Mill | 18. 18 | 39. 06 | 121. 61 | 6, 448. 6 | Do. |
| Tularosa | 17. 27 | 56. 33 | 104. 34 | 4, 357. 5 | Government agency; town. |
| White Sands | 25. 78 | 82. 11 | 78. 56 | 3, 888. 3 | Water strongly alkaline; poor grazing; little fuel. |
| Shedd's Ranch | 30. 80 | 112. 91 | 47. 76 | 4, 378. 0 | Government agency; good grazing. |
| Fort Bliss | 47. 76 | 160. 67 | ........ | 3, 622. 9 | Three-company post. |
| White Sands | ........ | ........ | 35. 07 | 3, 888. 3 | |
| San Nicolas Spring | 17. 07 | 17. 07 | 18. 00 | 4, 218. 0 | Good water; fuel and poor grazing. |
| Shedd's Ranch | 18. 00 | 35. 07 | ........ | 4, 378. 0 | |
| Shedd's Ranch— | | | | | |
| Fort Selden | 28. 62 | ........ | ........ | ........ | |
| Las Cruces | 19. 80 | ........ | ........ | ........ | |

## LIST OF ROAD-DISTANCES BETWEEN PROMINENT POINTS MEANDERED BY PARTY NO. 1, UTAH SECTION, 1878.

Chico, Cal., to Taylorville, Cal.
Chico, Cal., to Sesma, Cal.
Sesma, Cal., to Prattville, Cal.
Oroville, Cal., to Quincy, Cal.
Quincy, Cal., to Taylorville, Cal.
Taylorville, Cal., to Quincy, Cal.
Red Bluff, Cal., to Susanville, Cal.
Susanville, Cal., to Red Bluff, Cal.

*From Chico to Taylorville, Cal.—Atlas-sheets Nos.* 47 *C and A.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Chico. | From Taylorville. | | |
| Chico, post-office | ........ | ........ | 91. 12 | 177. 3 | Via Butte Creek road, Prattville, and Arlington Bridge. |
| Centerville | 12. 95 | 12. 95 | 78. 17 | 502. 5 | Wood and water; no pasturage. |
| Hupp's Mill | 9. 55 | 22. 50 | 68. 62 | 2, 667. 0 | Do. |
| Inskip | 10. 71 | 33. 21 | 57. 91 | 4, 808. 3 | Do. |
| Chapperal House | 3. 90 | 37. 11 | 54. 01 | 5, 076. 0 | Do. |
| Butte Creek House | 7. 67 | 44. 78 | 46. 34 | 5, 758. 1 | Wood, water, and pasturage. |
| Longville | 11. 63 | 56. 41 | 34. 71 | 4, 309. 0 | Toll-gate; water; pasturage. |
| Prattville | 8. 67 | 65. 08 | 26. 04 | 4, 394. 1 | Town; pasturage. |
| Greenville | 14. 91 | 79. 99 | 11. 13 | 3, 543. 8 | Pasturage near town. |
| Crescent City | 4. 98 | 84. 97 | 6. 15 | 3, 306. 0 | Do. |
| Arlington Bridge | 1. 30 | 86. 27 | 4. 85 | 3, 375. 0 | Pasturage, wood, and water. |
| Taylorville | 4. 85 | 91. 12 | ........ | 3, 479. 0 | Do. |

*From Chico to Taylorville, Cal.—Atlas-sheets Nos.* 47 *C and A*—Continued.

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Chico. | From Taylorville. | | |
| Chico | ........ | ........ | 89.826 | 177.3 | Via Chico Creek toll-road, Prattville, and Deadfall Bridge. |
| Weld's | 15.980 | 15.980 | 73.846 | 2,217.4 | Wood and water; no pasturage. |
| Lomo | 13.566 | 29.546 | 44.300 | 3,847.8 | Do. |
| Colby's | 9.884 | 39.430 | 50.396 | 4,989.7 | Wood, water, and pasturage. |
| Toll-gate | 8.380 | 47.810 | 42.016 | 5,426.6 | Do. |
| Butte Creek Bridge | 8.108 | 55.918 | 33.908 | 4,691.6 | Do. |
| Prattville | 7.418 | 63.336 | 26.490 | 4,394.1 | Town; pasturage. |
| Greenville | 14.910 | 78.246 | 11.580 | 3,543.8 | Do. |
| Deadfall Bridge | 9.730 | 87.976 | 1.850 | 3,426.0 | Wood, water, and pasturage. |
| Taylorville | 1.850 | 89.826 | ........ | 3,479.0 | Town; pasturage. |

*From Chico to Sesma, Cal.—Atlas-sheets Nos.* 46 *B and D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Chico. | From Sesma. | | |
| Chico | ........ | ........ | 26.696 | 177.3 | Town. |
| Phillip Ranch | 12.138 | 12.138 | 14.558 | 242.1 | Ranch; wood scarce; water and pasturage. |
| Sesma | 14.558 | 26.696 | ........ | 260.0 | Williamson's store. |

*From Sesma to Prattville, Cal.—Atlas-sheets Nos.* 46 *B and* 47 *A.*

| | | | | | |
|---|---|---|---|---|---|
| Sesma | ........ | ........ | 61.653 | 259.7 | Via Lassen's old trail; abandoned wagon-road. |
| Deer Creek Meadows | 44.000 | 44.000 | 17.653 | 4,518.1 | Junction Deer and Lost Creeks, lower end meadows. |
| Prattville | 17.653 | 61.653 | ........ | 4,394.1 | Town. |

*From Oroville to Quincy, Cal.—Atlas-sheets Nos. 47 C and A.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Oroville. | From Quincy. | | |
| Oroville | ........ | ........ | 64. 384 | 187. 5 | At Toll Bridge over river. |
| Bidwell's Bar | 9. 500 | 9. 500 | 54. 884 | 342. 1 | Good water; no grass; forage obtainable. |
| Berry Creek | 9. 096 | 18. 596 | 45. 788 | 1, 887. 2 | Do. |
| Junction House | 10. 512 | 29. 108 | 35. 276 | 3, 562. 2 | Do. |
| Buckeye | 5. 325 | 34. 433 | 29. 951 | 4, 938. 0 | Stage station. |
| Buck's Ranch | 13. 368 | 47. 801 | 16. 583 | 5, 112. 2 | Good pasturage obtainable. |
| Toll gate | 5. 605 | 53. 406 | 10. 978 | 5, 426. 6 | Unfit for camping. |
| Meadow Valley | 2. 380 | 55. 786 | 8. 598 | 3. 757. 0 | Wood and water; forage obtainable. |
| Spanish Ranch | 1. 932 | 57. 718 | 6. 666 | 3, 636. 0 | Wood and water; pasturage obtainable. |
| Quincy | 6. 666 | 64. 384 | ........ | 3, 381. 0 | Wood and water; forage and pasturage. |

*From Quincy to Taylorville, Cal.—Atlas-sheet No. 47 A.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Quincy. | From Taylorville. | | |
| Quincy | ........ | ........ | 21. 170 | 3, 381 | Forage and pasturage obtainable. |
| Shoo-fly Bridge | 12. 90 | 12. 900 | 8. 270 | 3, 071 | |
| Arlington Bridge | 3. 42 | 16. 320 | 4. 850 | 3, 375 | |
| Taylorville | 4. 85 | 21. 170 | ........ | 3. 479 | Forage and pasturage obtainable. |
| Quincy | ........ | ........ | ........ | 3, 381 | Via old toll-road. |
| Taylorville | 15. 30 | ........ | ........ | 3, 479 | Taylor's Hotel. |

*From Taylorville to Quincy, Cal.—Atlas-sheet No. 47 A.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Taylorville. | From Quincy. | | |
| Taylorville | ........ | ........ | 81. 438 | 3, 479. 0 | Taylor's Hotel. |
| *Hosselkus' Ranch | 6. 875 | 6. 875 | 74. 563 | 3, 635. 0 | Genesee Valley. |
| Flournoy's Ranch | 3. 966 | 10. 841 | 70. 597 | ........ | Pasturage and forage obtainable. |
| *Bagley's Ranch | 11. 500 | 22. 341 | 59. 097 | 5, 387. 0 | Do. |
| Crow's Ranch | 7. 500 | 29. 841 | 51. 597 | 5, 464 0 | Do. |
| Beckworth's Store | 9. 400 | 39. 241 | 42. 197 | 4, 887. 2 | Forage. |
| Delaney's Ranch | 9. 371 | 48. 612 | 32. 826 | 4, 840. 0 | Pasturage. |
| Parker's Ranch | 16. 256 | 64. 868 | 16. 570 | 4, 135. 7 | Do. |
| Quincy | 16. 570 | 81. 438 | ........ | 3, 381. 0 | Town. |

*From Hosselkus' to Bagley's Ranch the distance is estimated by pacing.

*From Red Bluff to Susanville, Cal.—Atlas-sheets Nos.* 46 *B and A.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Red Bluff. | From Susanville. | | |
| Red Bluff | ........ | ........ | 107.936 | 307.6 | Railroad track at depot, from railroad profiles. |
| Bell Mill | 37.229 | 37.229 | 70.707 | 3,681.2 | No feed; wood and water. |
| Battle Creek Meadows | 9.728 | 46.957 | 60.979 | 4,699.7 | Toll-gate; wood and water; pasturage. |
| *Tyler's Ranch | 8.455 | 55.412 | 52.524 | 4,801.7 | Wood and water; pasturage. |
| *Willow Creek | 10.250 | 65.662 | 42.274 | ........ | Wood and water; no pasturage. |
| Warner Creek Bridge | 1.479 | 67.141 | 40.795 | 4,826.2 | Do. |
| Forks of road near Martin's Ranch | 5.500 | 72.641 | 35.295 | 4,464.0 | To Prattville, along west side Big Meadows, 9.324 miles. |
| Forks of road near Mitchell's Ranch | 4.670 | 77.311 | 30.625 | 4,713.4 | To Prattville, along east side Big Meadows, 17.200 miles. |
| Goodrich's Ranch | 12.365 | 89.676 | 18.260 | 4,883.0 | |
| Susanville | 18.260 | 107.936 | ........ | 4,195.0 | Town; post-office. |

* From Tyler's Ranch to Willow Creek, distance estimated.

*From Susanville, to Red Bluff, Cal.—Atlas-sheets Nos.* 47 *A and* 46 *B.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Susanville. | From Red Bluff. | | |
| Susanville | ........ | ........ | 133.123 | 4,195.1 | Via Pine Creek, Canoe Creek, and Ogburn's Ranch to Jelly's Ferry. |
| * Forks road (near Stockton's Mill) | 7.185 | 7.185 | 125.938 | 5,036.4 | Wood, water, pasturage at Stockton's. |
| Bridge Creek | 12.000 | 19.185 | 113.938 | 5,508.6 | Wood, water, grazing. |
| Pine Creek | 10.000 | 29.185 | 103.938 | 5,409.1 | Do. |
| Canoe Creek | 26.700 | 55.885 | 77.238 | 4,277.0 | Wood, water, grazing one mile below junction Lost and Hat Creek. |
| Loomis' Ranch | 20.724 | 76.609 | 56.514 | 4,356.5 | Wood, water, pasturage at Smith's, distance 0.5 mile. |
| Ogburn's Ranch | 17.050 | 93.659 | 39.464 | 2,269.5 | Do. |
| † Jelly's Ranch | 27.464 | 121.123 | 12.000 | 360.0 | Do. |
| Red Bluff (via ferry) | 12.000 | 133.123 | ........ | 307.6 | Town; altitude at railroad depot. |

* From forks of road, near Stockton's Mill, to Pine Creek the distance was estimated by pacing.
† From Red Bluff to Jelly's Ranch popular estimate of distance given.

## LIST OF ROAD DISTANCES BETWEEN PROMINENT POINTS MEANDERED BY PARTY NO. 2, UTAH SECTION, 1878.

Bakersfield to Caliente, Cal.
Caliente to Twin Lakes, Cal.
Caliente to Havilah, Cal.
Houlton's Ranch to Lone Valley Mines, Cal.
Kern River Bridge to Wilkes' Ranch, Cal.
Little Elizabeth Lake to San Fernando Mission, Cal.
Roberts' Ranch to Weldon, Cal.
Tapo Ranch to Hueneme, Cal.
Miscellaneous distances, California.

*From Bakersfield to Caliente, Cal.—Atlas-sheet No. 73 A.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Bakersfield. | From Caliente. | | |
| Bakersfield | | | | | Railroad station. |
| Pampa | 16.48 | | | | By road. No grass; no wood. |
| Caliente | 7.22 | 23.70 | | | No trail, via the cañon. |

*From Caliente to Twin Lakes, Cal.—Atlas-sheet No. 73 A.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Caliente. | From Twin Lakes. | | |
| Caliente | | | 43.33 | | |
| Beale Station | 1.57 | 1.57 | 41.76 | | By road. On the Southern Pacific Railroad. |
| Soap Creek | 15.16 | 16.73 | 26.60 | | By road and trail. Water, wood, and grass here. |
| Tejon Ranch | 9.97 | 26.70 | 16.63 | | By trail. Farming and grazing country. |
| McKenzie's | 11.16 | 37.86 | 5.47 | | By road. Tejon Creek. |
| Twin Lakes | 5.47 | 43.33 | | | By trail. Old emigrant camping ground. Good water and wood; grass scanty. |

*From Caliente to Havilah, Cal.—Atlas-sheet No. 73 A.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Caliente. | From Havilah. | | |
| Caliente | | | 52.25 | | |
| Pampa | 12.37 | 12.37 | 39.88 | | Via Kernville stage road. |
| Stark's Ranch | 1.03 | 13.40 | 38.85 | | Walker's Basin Creek. |
| Kern River | 9.84 | 23.24 | 29.01 | | Mouth Cottonwood Creek. Barker's Ranch, 1 mile below. |
| Mouth of Kern River Cañon | 2.02 | 25.26 | 26.99 | | |
| Oak Creek | 4.42 | 29.68 | 22.57 | | Water and grass scanty. |
| Kerr Creek | 3.96 | 33.64 | 18.61 | | Spring of water ½ mile below crossing of road. |
| Breckenridge Mountain | 9.63 | 43.27 | 8.98 | | Jewitt's Ranch. |
| Havilah | 8.98 | 52.25 | | | |

This route is very circuitous. The direct road from Caliente to Havilah and Kernville was surveyed in 1875.

From Stark's Ranch to Breckenridge Mountain, by trail; from Breckenridge Mountain to Havilah, by road.

*From Houlton's Ranch to Lone Valley Mines, Cal.—Atlas-sheet No. 73 D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Houlton's Ranch. | From Lone Valley Mines. | | |
| Houlton's | | | 54.63 | | Large grazing ranch. |
| Forks of the Mojave | 5.26 | 5.26 | 49.37 | | By road. But little grass; water and wood in abundance. |
| Rattlesnake Spring | 16.97 | 22.23 | 32.40 | | By road, to the left of the main road. |
| Cox's Cabin | 3.78 | 26.01 | 28.62 | | By road; good grazing, water, and wood. |
| Green Lead Mining Camp | 6.43 | 32.44 | 22.19 | | By road; deserted now. |
| Holcomb Valley | 7.52 | 39.96 | 14.67 | | By road; placer and quartz mines; small settlement. |
| Bear Valley | 4.34 | 44.30 | 10.33 | | By road; mining town; forage may be purchased. |
| Lone Valley Mines | 10.33 | 54.63 | | | By trail; no grass; water scarce. |

*From Kern River Bridge to Wilkes' Ranch, Cal.—Atlas-sheet No. 73 A.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Kern River Bridge. | From Wilkes' Ranch. | | |
| Kern River Bridge | | | 37.52 | | Stage crossing; south of Kernville. |
| Keysville | 1.83 | 1.83 | 35.69 | | By road; old mining-camp. |
| Dahlonega Hot Springs | 10.19 | 12.02 | 25.50 | | By road and trail; on Kern River. |
| Poso Creek | 12.87 | 24.89 | 12.63 | | Poor trail; mouth of Badger Gulch. |
| Mouth of Little Poso Creek | 3.04 | 27.93 | 9.59 | | Trail. |
| Poso Flat | 4.94 | 32.87 | 4.65 | | Trail; Gardet's Ranch; cultivated ground. |
| Wilkes' Ranch | 4.65 | 37.52 | | | On the county road. |

*From Little Elizabeth Lake to San Fernando Mission, Cal.—Atlas-sheet No. 73 C.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Elizabeth Lake. | From San Fernando Mission. | | |
| Little Elizabeth Lake | | | 45.08 | | Entrance to Castac Cañon; numerous farms here. |
| Forks of Castac Creek | 19.36 | 19.36 | 25.72 | | No trail; via Castac Cañon. |
| Newhall's Ranch | 6.35 | 25.71 | 19.37 | | By road; Santa Clara River. |
| Leighton's | 7.04 | 32.75 | 12.33 | | By road; store and ranch; on the road to the Pico oil-wells. |

*From Little Elizabeth Lake to San Fernando Mission, Cal., &c.*—Continued.

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Elizabeth Lake. | From San Fernando Mission. | | |
| Brophy's | 3.54 | 36.29 | 8.79 | | By road; grain and grazing ranch. |
| Summit of trail | 2.20 | 38.49 | 6.59 | | By trail. |
| San Fernando Tunnel | 1.13 | 39.62 | 5.46 | | By trail; Southern Pacific Railroad. |
| Lopez Station | 4.10 | 43.72 | 1.36 | | By road. |
| San Fernando Mission | 1.36 | 45.08 | | | By road; gardens and grain ranches. |

*From Roberts' Ranch to Weldon, Cal.—Atlas-sheet No. 73 A.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Roberts' Ranch. | From Weldon. | | |
| Roberts' Ranch | | | 52.14 | | South Fork Kern River. |
| The Canebrake | 5.63 | 5.63 | 46.51 | | Ranch here; good camping-ground. |
| Summit, Walker's Pass | 6.23 | 11.86 | 40.28 | | |
| Coyote Holes | 7.28 | 19.14 | 33.00 | | On the desert; stage station; water plenty; feed scarce. |
| Bird Spring | 12.28 | 31.42 | 20.72 | | Good spring; no grass; no wood. |
| Weldon | 21.72 | 52.14 | | | Farming country. |

Continuous road from Roberts' Ranch to Weldon.

*From Tapo Ranch to Hueneme, Cal.—Atlas-sheet No. 73 C.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Tapo Ranch. | From Hueneme. | | |
| Tapo Ranch | | | 51.39 | | Vineyard and cultivated ground. |
| Simi Ranch | 7.14 | 7.14 | 44.25 | | By road; country devoted to sheep-raising. |
| Las Posas Ranch | 12.42 | 19.56 | 31.83 | | By road; grain and sheep ranch. |
| New Jerusalem | 11.95 | 31.51 | 19.88 | | By road; good farming country. |
| San Buenaventura | 8.08 | 39.59 | 11.80 | | By road; at the old mission church. |
| Hueneme | 11.80 | 51.39 | | | Along the coast; no trail; harbor and wharves here. |

### *Miscellaneous distances, California—Atlas-sheet No. 73 C.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From— | From— | | |
| Calleguas Ranch | ........ | ........ | 7.61 | .......... | Wine ranch. |
| Conejo Hotel | 7.61 | 7.61 | ........ | .......... | By road; in the Conejo Valley; grain and grazing in abundance. |
| Springville | ........ | ........ | 27.58 | .......... | Farming country. |
| Conejo Hotel | 15.81 | 15.81 | 11.77 | .......... | By road. |
| Newberry Park | 4.39 | 20.20 | 7.38 | .......... | By road; oak forests. |
| Mill's Ranch | 1.97 | 22.17 | 5.41 | .......... | By road. |
| The Potrero | 5.41 | 27.58 | ........ | .......... | By road; large and fertile valley; numerous ranches. |
| Mill's Ranch | ........ | ........ | 9.17 | .......... | |
| Vejar's Ranch | 9.17 | 9.17 | ........ | .......... | By road, via Triunfo Creek. |

### *Miscellaneous distances, California—Atlas-sheet No. 73 C.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From— | From— | | |
| Los Angeles | ........ | ........ | 20.22 | .......... | |
| Half-way House | 9.24 | 9.24 | 10.98 | .......... | By road; on the Santa Monica road. |
| Santa Monica | 6.92 | 16.16 | 4.06 | .......... | By road; summer resort. |
| Old Santa Monica | 1.80 | 17.96 | 2.26 | .......... | Along the coast; mouth of Santa Monica Creek. |
| Santa Inez Cañon | 2.26 | 20.22 | ........ | .......... | Along the coast; no grass; water poor; wood scarce. |
| Los Angeles | ........ | ........ | 4.03 | .......... | |
| Sycamore Grove | 4.03 | 4.03 | ........ | .......... | By road; pic-nic grounds in the Arroyo Seco. |
| San Gabriel Mission | ........ | ........ | 33.09 | .......... | |
| Roberts' Ranch | 13.52 | 13.52 | 19.57 | .......... | By road; mouth of San Gabriel Cañon. |
| Winston Silver mines | 3.44 | 16,96 | 16.13 | .......... | By road; feed in San Gabriel Cañon very scarce; scanty bunch grass in places; wood and water abundant. |
| Forks of San Gabriel Creek | 5.76 | 22.72 | 10.37 | .......... | |
| San Gabriel Mines | 2.21 | 24.93 | 8.16 | .......... | |
| Mouth of Cattle Cañon | 2.81 | 27.74 | 5.35 | .......... | By road; cattle range in this cañon; good trout-fishing. |
| The Narrows | 5.35 | 33.09 | ........ | .......... | By trail; cañon impassable farther. |

*Miscellaneous distances, California.—Atlas-sheet No. 73 D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From— | From— | | |
| **Kincaid's Ranch** | | | 4.06 | | Mouth of San Antonio Cañon. |
| **The Falls** | 4.06 | 4.06 | | | Cienega at the foot of the rapids. |
| **Kincaid's Ranch** | | | 24.62 | | Fruit and grain ranch. |
| **Cucamonga** | 6.40 | | 18.22 | | By road; large vineyards here. |
| **San Bernardino** | 18.22 | 24.62 | | | By road; town. |
| **Forks of Santa Ana River** | | | 16.65 | | Grass very scarce; meadow a few miles above. |
| **Fish-pond Ranch** | 5.80 | 5.80 | 10.85 | | By trail; Good grazing here. |
| **Mountain Home** | 5.83 | 11.63 | 5.02 | | By trail; summit of pass; no feed; wood and water abundant. |
| **Forsee's Ranch** | 5.02 | 16.65 | | | By trail: on Mill Creek. |

*Miscellaneous distances, California.—Atlas-sheet No. 73 D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From— | From— | | |
| **San Bernardino** | | | 12.68 | | |
| **Devil's Cañon Toll-house** | 7.86 | 7.86 | 4.82 | | By road; good camping-ground. |
| **Summit** | 4.04 | 11.90 | .78 | | By road. |
| **Clipper Saw-mill** | 0.78 | 12.68 | | | By road; road from here to Houlton's Ranch. |
| **Summit** | | | 11.86 | | |
| **Fiddler's Tannery** | 4.69 | 4.69 | 7.17 | | Old road; wood, water, and grass. |
| **Whiskey Johnny's** | 4.69 | 9.38 | 2.48 | | Old road; summit of toll-road. |
| **Little Bear Valley** | 2.48 | 11.86 | | | By road; large grazing area; saw-mills here. |
| **Waterman's Hot Springs** | | | 16.66 | | Fruit and grain ranch; resort for invalids. |
| **San Bernardino** | 6.08 | 6.08 | 10.58 | | |
| **Colton** | 3.24 | 9.32 | 7.34 | | Railroad station for San Bernardino. |
| **Riverside** | 7.34 | 16.66 | | | Orange-growing region. |

## LIST OF DISTANCES BETWEEN PROMINENT POINTS MEANDERED BY PARTY NO. 2, CALIFORNIA SECTION, 1878.

Camp Bidwell, Cal., to Fort Klamath, Oreg.
Fort Klamath, Oreg., to Warm Spring Agency, Oreg.
Warm Spring Agency, Oreg., to The Dalles, Oreg.
The Dalles, Oreg., to Lower Cascades, Oreg.

The Dalles, Oreg., to ferry at Grant's Landing, and thence to Tygh Valley, via Shear's Bridge, Oreg.
Warm Spring Agency, Oreg., to Camp Bidwell, Cal.
Oak Grove, Oreg., to Toll-gate Well of Mount Hood, via new grade.
Summit Prairie, near Mount Hood, to Tygh Valley, via Barlow's Toll-gate.
Old Camp Watson, Oreg., to Camp Bidwell, Cal.
The Dalles, Oreg., to Old Camp Watson, Oreg.
Camp Bidwell, Cal., to Reno, Nev.

*From Camp Bidwell, Cal., to Fort Klamath, Oreg.—Atlas-sheet No.* 38 *A and B, and* 29 *C.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Camp Bidwell. | From Fort Klamath. | | |
| Camp Bidwell | | | 145.8 | | Two-company post. |
| Willow Ranch | 16.89 | 16.89 | 128.91 | | Small settlement; water, wood, and grass. |
| Lake View | 19.21 | 36.10 | 109.70 | | Small town; United States Land Office; water, wood, and grass. |
| Phelp's Ranch | 20.34 | 56.44 | 89.36 | | Water, wood, and grass. |
| Prine's Ranch | 28.39 | 84.83 | 60.97 | | Good grazing, water, and wood. |
| Yainax | 16.34 | 101.17 | 44.63 | | Sub-agency for Klamath Indians; water, wood and grass. |
| Klamath Agency | 38.53 | 139.70 | 6.1 | | Water, wood, and grass. |
| Fort Klamath | 16.1 | 145.8 | | | Two-company post; good grazing; water and wood in vicinity. |

*From Fort Klamath to Warm Spring Agency, Oreg.—Atlas-sheets Nos.* 29 *C,* 29 *A, and* 20 *C.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | Fort Klamath. | From Warm Spring Agency. | | |
| Fort Klamath | | | 202.25 | 4,108.4 | Two-company post; water, wood, and grass in vicinity. |
| Klamath Agency | 6.1 | 6.1 | 196.15 | | |
| Williamson River | 11.7 | 17.8 | 184.45 | 4,387.0 | Good water, wood, and grass. |
| Big Springs | 22.85 | 40.65 | 161.60 | 4,552.5 | Do. |
| Corral Springs | 21.64 | 62.29 | 139.96 | 4,782.6 | Do. |
| Little Meadows, on East Fork of Des Chutes. | 17.10 | 79.39 | 122.86 | 4,258.2 | Good grazing, water, and wood. |
| East Fork of Des Chutes | 21.74 | 101.13 | 101.12 | 4,081.1 | Do. |
| Big Meadows | 13.90 | 115.03 | 87.22 | 4,123.7 | Do. |
| Farewell Bend | 15.80 | 130.83 | 71.42 | 3,620.9 | Good grazing, wood, and water off the road; ranch taken up near road and fenced in. |
| Carmical's, on Crooked River | 25.84 | 156.67 | 45.58 | 2,736.2 | Poor grazing; a little wood; water good; forage can be bought. |
| Luera Ranch | 15.1 | 171.77 | 30.48 | 2,443.4 | Water, wood, and grass. |
| Sheep Ranch | 10.83 | 182.60 | 19.65 | | Do. |
| Lodge Pole Creek | 13.73 | 196.33 | 5.92 | | Good water and grass; wood scarce. |
| Des Chutes Ferry | 3.61 | 199.94 | 2.31 | | Grass and wood scarce. |
| Warm Spring Agency | 2.31 | 202.25 | | 1,573.9 | Wood scarce; grass on hills in vicinity. |

*From Warm Spring Agency to The Dalles, Oreg.—Atlas-sheets Nos.* 20 *C and* 20 *A.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Warm Spring Agency. | From The Dalles, Oregon. | | |
| Warm Spring Agency | ........ | ........ | 74.25 | 1,513.9 | Wood scarce; grass on hills in vicinity. |
| Neenee Spring | 20.45 | 20.45 | 53.80 | 2,914.2 | Good water; wood and grass. |
| Oak Grove | 6.25 | 26.70 | 47.55 | 2,414.5 | Small settlement; water, wood, and grass. |
| Tygh Valley | 15.76 | 42.46 | 31.79 | 1,088.8 | Settlement; forage has to be bought. |
| Fifteen-mile Creek | 17.00 | 59.46 | 14.79 | 1,266.7 | Do. |
| The Dalles, Oregon | 14.79 | 74.25 | ........ | 134.7 | Large town on Columbia River. |

Distances estimated to Fifteen-mile Creek.

*From The Dalles to Lower Cascades, Oreg.—Atlas-sheet No.* 20 *A.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From The Dalles, Oregon. | From Lower Cascades. | | |
| The Dalles | ........ | ........ | 50.05 | 134.7 | Large town. |
| Mosher Creek | 13.01 | 13.01 | 37.04 | .......... | Water, wood, and grass. |
| Herk's Ranch | 5.70 | 18.71 | 31.34 | .......... | Grass scarce; water and wood; forage can be purchased. |
| Hood River | 4.39 | 23.10 | 26.95 | 260.0 | Ranch; grass scarce; water and wood; forage can be purchased. |
| Hood River Post-office | 0.51 | 23.61 | 26.44 | .......... | Ranch. |
| Hotel | 0.6 | 24.21 | 25.84 | .......... | No grass; water and wood. |
| Upper Cascades | 20.89 | 45.10 | 4.95 | 126.6 | Good grass; wood. |
| Lower Cascades | 4.95 | 50.05 | ........ | .......... | Do. |

*From The Dalles to Ferry at Grant's Landing, and thence to Tygh Valley via Shear's Bridge, Oreg.—Atlas-sheet No. 20 A.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From The Dalles. | From Tygh Valley. | | |
| The Dalles | ........ | ........ | 84.82 | 134.7 | Large town. |
| Five-mile House | 6.55 | 6.55 | 77.27 | .......... | Junction of Eight and Five Mile Creeks; country rather barren; no wood. |
| Fifteen-mile Creek | 5.10 | 11.65 | 72.17 | .......... | Grass scarce; no wood; ranch. |
| Bridge over Des Chutes River, near Celilo. | 5.62 | 17.27 | 66.55 | 165.8 | Ranch; no wood; grass scarce; forage for sale here. |
| Ranch | 10.19 | 27.46 | 56.36 | .......... | Water and grass; wood very scarce. |
| Springs in ravine near Grant's Landing. | 1.21 | 28.67 | 55.15 | .......... | Good water; grass and wood scarce. |
| Eaton's Ranch Post-office | 8.8 | 37.47 | 47.35 | .......... | Good grazing and water; no wood. |
| Barnum's Ranch | 11.32 | 48.79 | 36.03 | 1,795.2 | Grass valley; no wood; good water and grass. |
| Shear's Bridge | 28.54 | 77.33 | 7.49 | 2,006.9 | No wood; grass scarce; forage can be purchased. |
| Tygh Valley | 7.59 | 84.82 | ........ | 1,088.8 | Settlement; forage has to be purchased; some grazing on hills surrounding settlement. |

*From Warm Spring Agency, Oreg., to Camp Bidwell, Cal.—Atlas-sheets Nos. 29 A, 38 B, 20 C, and 29 C.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Warm Spring Agency. | From Camp Bidwell. | | |
| Warm Spring Agency | ........ | ........ | 258.09 | 1,513.9 | Wood scarce; grass on hills in vicinity. |
| Lodge-pole Creek | 5.92 | 5.92 | 252.17 | 1,648.3 | Good grass and water; wood scarce. |
| Willow Creek | 20.72 | 26.64 | 231.45 | 3,079.6 | Water, wood, and grass. |
| Prineville | 21.02 | 47.66 | 210.43 | 2,899.0 | Large town; forage can be purchased; wood and grass on hills in vicinity. |
| Green's Ranch | 25.90 | 73.56 | 184.53 | 4,479.0 | Water, wood, and grass. |
| Waterhole | 12.8 | 86.36 | 171.73 | .......... | No wood; good grass; water in deep hole. |
| Langton's Ranch | 17.71 | 104.07 | 154.02 | 5,162.9 | Water, wood, and grass. |
| Button's Ranch | 22.9 | 126.97 | 131.12 | 4,236.7 | Wood, none; water, good; grass, scarce; forage can be purchased. |
| Durand's Ranch (Silver Lake) | 19.9 | 146.87 | 111.22 | 4,312.0 | Forage has to be purchased. |
| Parton's Ranch (Summer Lake) | 15.91 | 162.78 | 95.31 | 4,497.6 | Water, wood, and grass. |
| Miller's Ranch (Summer Lake) | 17.31 | 180.09 | 78.00 | 4,420.3 | Do. |
| Chewaucan | 8.93 | 189.02 | 69.07 | .......... | |
| Moss's Ranch | 11.67 | 200.69 | 57.40 | 4,827.8 | Forage has to be purchased. |
| Saw-mill | 9.52 | 210.21 | 47.88 | .......... | Grass and water on hills in vicinity. |
| Lake View | 17.87 | 228.08 | 30.01 | 4,851.0 | Settlement; U. S. land-office; water, wood, and grass. |
| Cottonwood Creek | 18.7 | 246.78 | 11.31 | 5,228.9 | Plenty of good water, wood, and grass; new grade. |
| Camp Bidwell | 11.31 | 258.09 | ........ | 4,647.0 | Two-company post; new grade. |

*From Oak Grove to Toll-gate west of Mount Hood, Oreg., via new grade.—Atlas-sheet No. 20 A.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Oak Grove. | From Toll-gate. | | |
| Oak Grove | | | 49.22 | 2,414.5 | Settlement; grass, wood, and water. |
| Kamas Prairie | 17.5 | 17.5 | 31.72 | 3,019.8 | Water, wood, and grass. |
| Big Prairie | 12.71 | 30.21 | 19.01 | 3,334.8 | Water, wood, and grass; rather swampy. |
| *Summit Prairie | 8.3 | 38.51 | 10.71 | 3,694.2 | Station; forage can be bought; some grass on meadows near there. |
| †Government Camp | 2.27 | 40.78 | 8.44 | | Water, wood, and grass; rather marshy. |
| Toll-gate, foot of range | 8.44 | 49.22 | | | Wood and water; forage must be bought. |

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* From this place only the ascent of Mount Hood is possible.

† Good grass can be found on slope of Mount Hood, about 1.5 miles northeast of government camp.

*From Summit Prairie, near Mount Hood, to Tygh Valley, via Barlow Toll-gate.—Atlas-sheet No. 20 A.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Summit Prairie. | From Tygh Valley. | | |
| *Summit Prairie | | | 39.04 | 3,694.2 | Station; forage can be bought; grass on some meadows near by. |
| White River | 11.64 | 11.64 | 27.40 | 3,000.3 | Wood and water; grass rather scarce. |
| Barlow Toll-gate or Stricklin's Ranch. | 14.52 | 26.16 | 12.88 | | Water, wood, and grass; ranch. |
| Tygh Valley | 12.88 | 39.04 | | 1,111.4 | Settlement; forage must be purchased. |

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* From this place only the ascent of Mount Hood is possible.

*From Old Camp Watson, Oreg., to Camp Bidwell, Cal.—Atlas-sheets Nos.* 20 *D*, 29 *B*, 29 *D and* 38 *B*.

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Old Camp Watson. | From Camp Bidwell. | | |
| Old Camp Watson | | | 243.27 | .......... | |
| McNeal's Ranch | 4.00 | 4.00 | 239.27 | .......... | Good water and grass. |
| Old Military Road | 5.56 | 9.56 | 233.71 | .......... | |
| Small Prairie | 1.30 | 10.86 | 232.41 | .......... | Good water and grass. |
| Creek | 5.50 | 16.36 | 226.91 | .......... | Do. |
| Summit Prairie | 4.55 | 20.91 | 221.36 | .......... | Do. |
| Ranch, Paulina Valley | 13.20 | 34.11 | 208.16 | .......... | Do. |
| Prineville and Harney Road | 3.55 | 37.66 | 204.61 | .......... | |
| Wolf Creek (settlement) | 2.90 | 40.56 | 201.71 | .......... | Good water; feed can be bought. |
| Ranch (Beaver Creek, near mouth of Grindstone Creek). | 3.45 | 44.01 | 198.26 | .......... | Do. |
| Big Spring | 3.88 | 47.89 | 194.38 | .......... | Good water and grass. |
| Ranch | 1.90 | 49.79 | 192.48 | .......... | Good water; feed can be bought. |
| Prineville and Harney Road | 4.50 | 54.29 | 187.98 | .......... | |
| Spring, head of Grindstone Creek. | 1.35 | 55.64 | 186.63 | .......... | Good water and grass. |
| Dillard & Renshaw's Ranch, Twelve-mile Creek. | 4.86 | 60.50 | 181.77 | .......... | Water and grass. |
| Forks of road, near mouth of Long Hollow. | 1.90 | 62.40 | 179.87 | .......... | |
| Spring in Long Hollow | 3.85 | 66.25 | 176.02 | .......... | Good water and grass. |
| Spring near head of Long Hollow | 3.70 | 69.95 | 172.32 | .......... | Do. |
| Buck Creek | 2.10 | 72.05 | 150.22 | .......... | Do. |
| Forks of road | 2.55 | 74.60 | 167.67 | .......... | |
| Alkali Flat | 7.30 | 81.90 | 160.37 | .......... | |
| Camp Curry | 2.90 | 84.80 | 157.47 | .......... | Good water and grass. |
| Bernard's Battle Ground | 12.86 | 97.66 | 144.61 | .......... | Do. |
| Hoskin's Ranch | 11.44 | 109.10 | 133.17 | .......... | Do. |
| Harney Lake Valley | 1.79 | 110.89 | 131.38 | .......... | Good grass. |
| Harney Road | 6.98 | 117.87 | 124.40 | .......... | |
| Warm Spring | 0.92 | 118.79 | 123.48 | .......... | Good water and grass. |
| Buzzard Cañon | 11.43 | 130.22 | 112.05 | .......... | Water and grass. |
| Mule Spring | 24.98 | 155.20 | 87.07 | .......... | Good water and grass. |
| North end Warner Valley | 4.60 | 160.80 | 82.47 | .......... | |
| Fork of roads | 7.09 | 167.89 | 75.38 | .......... | |
| Do | 7.20 | 175.09 | 68.18 | .......... | |
| Do | 18.23 | 193.32 | 49.95 | .......... | |
| Do | 2.25 | 195.57 | 47.70 | .......... | |
| Honey Creek | 0.35 | 195.92 | 47.35 | .......... | Good water and grass. |
| Jones' Ranch | 1.15 | 197.07 | 46.20 | .......... | Do. |
| Fork of roads | 3.15 | 200.22 | 43.05 | .......... | |
| Wallace's Ranch, Deep Creek | 13.65 | 213.87 | 29.40 | .......... | Good water and grass. |
| Twenty-mile Creek, south end of Warner Valley. | 6.30 | 220.17 | 23.10 | .......... | Do. |
| Fork of road, Twelve-mile Creek. | 9.55 | 229.72 | 13.55 | .......... | Do. |
| Do | 0.35 | 230.07 | 13.20 | .......... | Do. |
| Eight-mile Creek | 5.41 | 235.48 | 7.79 | .......... | Do. |
| Lake Annie | 3.12 | 238.60 | 4.67 | .......... | |
| Camp Bidwell | 4.67 | 243.27 | .......... | .......... | Town and post; two companies. |

Distances are by estimation, meander with odometer, and popular values.

*From The Dalles to Old Camp Watson, Oreg.—Atlas-sheets Nos.* 20 *A*, 20 *B*, *and* 20 *D*.

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From The Dalles. | From Old Camp Watson. | | |
| The Dalles | | | 122.40 | | |
| Three-mile Creek | 2.50 | 2.50 | 119.90 | | Good water and grass. |
| Five-mile Creek | 3.00 | 5.50 | 116.90 | | Do. |
| Eight-mile Creek | 2.95 | 8.45 | 113.95 | | Do. |
| Forks of road | 1.70 | 10.15 | 112.25 | | |
| Fifteen-mile Creek | 2.10 | 12.25 | 110.15 | | Good water and grass. |
| Dry Creek | 1.15 | 13.40 | 119.00 | | Do. |
| Ranch and Spring | 9.55 | 22.95 | 109.45 | | Do. |
| Tygh Hills | 2.75 | 25.70 | 96.70 | | |
| Shear's Bridge, Deschutes Post-office. | 4.40 | 30.10 | 92.30 | | Good water; feed can be bought. |
| Salt Spring | 8.75 | 38.85 | 83.55 | | |
| Bake Oven | 10.25 | 49.10 | 73.30 | | Good water; feed can be bought. |
| Cross Hollows | 8.00 | 57.10 | 65.30 | | Do. |
| Antelope Post-office | 6.75 | 63.85 | 58.55 | | Do. |
| Forks of road | 2.75 | 66.60 | 55.80 | | Good water and grass. |
| Spring | 1.05 | 67.65 | 54.75 | | Do. |
| Currant Creek Station | 6.65 | 74.30 | 48.10 | | Do. |
| Ranch mouth of Muddy Creek | 3.70 | 78.00 | 44.40 | | Do. |
| Cherry Creek | 7.50 | 85.50 | 36.90 | | Do. |
| Mouth of Cherry Creek, John Day River. | 1.05 | 86.55 | 35.85 | | Do. |
| Burnt Ranch Station | 4.75 | 91.30 | 31.10 | | Good water; feed can be bought. |
| Mouth of Bridge Creek | 0.71 | 92.01 | 30.39 | | |
| Bridge Creek Post-office | 5.59 | 97.60 | 24.80 | | Good water; forage can be bought. |
| Ranch Alkali Flat | 5.43 | 103.03 | 19.37 | | Do. |
| Settlement forks of road | 4.77 | 107.80 | 14.60 | | Do. |
| Ranch, Stage Station | 2.50 | 110.30 | 12.10 | | Good water and grass. |
| Mountain House | 6.35 | 116.65 | 5.75 | | Do. |
| McNeal's Ranch | 1.75 | 118.40 | 4.00 | | Do. |
| Old Camp Watson | 4.00 | 122.40 | | | |

Distances are by estimation; meander with odometer and popular values.

*From Camp Bidwell, Cal., to Reno, Nev.—Atlas-sheets Nos.* 38 *B*, 38 *D*, 47 *B*, *and* 47 *D*.

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Camp Bidwell. | From Reno. | | |
| Camp Bidwell | | | 190.42 | | Town and post; two companies. |
| Lake City | 16.32 | 16.32 | 174.10 | | Small town. |
| Cedarville | 8.65 | 24.97 | 165.45 | | Do. |
| Eagleville | 15.90 | 40.87 | 149.55 | | Post-office on Eagle Creek. |
| Bare's Ranch | 11.72 | 52.59 | 137.83 | | South end Surprise Valley; on Silver Creek. |
| Forks of road | 8.42 | 61.01 | 129.41 | | Road to Yuledad and Cold Spring. |
| Clark's Ranch | 2.87 | 63.88 | 126.54 | | Good water and feed. |
| Spring | 16.04 | 79.92 | 110.50 | | Water and grass. |
| Buffalo Station | 13.06 | 92.98 | 97.44 | | Do. |

*From Camp Bidwell, Cal., to Reno, Nev., &c.*—Continued.

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Camp Bidwell. | From Reno. | | |
| Buffalo Salt Works (Murphy's) | 14.73 | 107.71 | 82.71 | .......... | Very bad water; to Deep Hole 22.94 miles. |
| Sheep Head | 7.56 | 115.27 | 75.15 | .......... | Good water; forage can be bought. |
| Fish Spring | 27.55 | 142.82 | 47.60 | .......... | Do. |
| Newcomb's Ranch | 9.98 | 152.80 | 37.62 | .......... | Do. |
| Giles' and Bickford's Ranch | 2.15 | 154.95 | 37.47 | .......... | Good water. |
| Winter's Ranch | 0.80 | 155.75 | 34.67 | .......... | Good water and grass. |
| Yule Frank's | 1.57 | 157.32 | 33.10 | .......... | Good water; forage can be bought. |
| Chapman's | 0.70 | 158.02 | 32.40 | .......... | Do. |
| Warm Spring | 8.68 | 166.70 | 23.72 | .......... | Good water and grass; near head of Winnemucca Valley. |
| Junction House | 6.03 | 172.73 | 17.69 | .......... | Good water; forage can be bought. |
| Deep Wells | 4.92 | 177.65 | 12.72 | .......... | Do. |
| Forks of road near Quartz Mill | 10.84 | 188.49 | 1.93 | .......... | North edge Truckee Meadows. |
| Reno | 1.93 | 190.42 | .......... | .......... | Town; station C. P. and V. and T. Railroads. |

NOTE.—The distance from Deep Wells to Reno here given is via the new road. By the road traveled generally the distance is 2.63 miles greater.

## LISTS OF DISTANCES BETWEEN IMPORTANT POINTS ON ROADS MEANDERED BY PARTIES NOS. 1 AND 2, CALIFORNIA SECTION, DURING FIELD-SEASONS 1878–'79.

Chinese Camp to Yosemite Valley, via Big Oak Flat road.
Oakdale to Snelling.
Snelling to Merced.
Snelling to Yosemite Valley, via Coulterville road.
Merced to Mariposa, Cal.
Mariposa to Yosemite Valley, via Mariposa road.
Barnard's Hotel to various points in the Yosemite.
Bower Cave to Black's and Hennessy's Bridge.
Hites' Cove to Yosemite Valley.
Fresno Flat to Clark's (via the Madera road).
Fresno Flat to Crane Valley.
Snelling, Cal., to Lagrange and Thompson's Ferry.
Lagrange to Merced Falls and Cunningham's Ranch, on old Fort Miller road.
Mariposa, Cal., to Lewis' Ranch, Cal., via Moore Hill road.
Mariposa, Cal., to Bear Valley, Cal.
Hornitos to Merced via Indian Gulch and old Fort Miller road.
Hornitos to Bear Valley.
Hornitos to Redman's Ranch, Cathey's Valley, Cal.
Cathey's Valley, Cal., to Merced, Cal.
Thompson's Ferry to Crimea House.
Knight's Ferry Bridge to Chinese Camp.
Knight's Ferry Bridge to Byrnes's Ferry and Copperopolis.
Roberts's Ferry to Knight's Ferry Bridge.
New York Tent to Sonora, Cal.
Sonora to Jacksonville, Cal.
Bridgeport, Cal., to Mountain House, Cal., via cañon West Walker and Coleville.
Bridgeport, Cal., to Mountain House, via East Walker River road.
Sonora, Cal., to San Andreas, Cal.
Sonora, Cal., to Milton, Cal.
Sonora, Cal., to Northrup's, Cal., on Sonora and Mono road.
Northrup's, Cal., to Bridgeport, Cal., via Sonora and Mono road.
Carson, Nev., to Volcano, Cal., via Amador and Nevada wagon-road.

Carson, Nev., to Murphy's, Cal., via Silver Mountain and Big Tree road.
Calaveras Grove to Murphy's, Cal.
Murphy's, Cal., to Sonora, Cal.
West Point, Cal., to Calaveras Grove.
Antelope Springs to Volcano, via Antelope and Pine Grove Turnpike.
Hite's Cove to Mariposa road.

*From Chinese Camp, via Big Oak Flat Road, to Yosemite Valley, Cal.—Atlas-sheet No.* 56 *D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Chinese camp. | From Yosemite. | | |
| Chinese Camp Post-office | | | 62.45 | | Mining town. |
| Null's Ranch | 1.47 | 1.47 | 60.98 | 1,299 | |
| Jacksonville | 2.71 | 4.18 | 58.27 | 602 | Mining town on Tuolumne, near mouth of Wood's Cr'k. |
| Fruit Ranch | 1.03 | 5.21 | 57.24 | | Keith's orchard and vineyard. |
| Stevens Bar Ferry | 1.24 | 6.45 | 56.00 | 614 | Over Tuolumne River. |
| Culbertson's | 3.45 | 9.90 | 52.55 | 980 | Moccasin Vineyard on Moccasin Creek. |
| Priest's Hotel | 2.21 | 12.11 | 50.34 | 2,558 | Stage station. |
| Big Oak Flat | 1.07 | 13.18 | 49.27 | 2,823 | Mining town. |
| Groveland | 2.24 | 15.42 | 47.03 | 2,828 | Formerly 1st Garrotta. |
| Brewery | 0 82 | 16.24 | 46.21 | 2,838 | |
| 2d Garrotta | 1.33 | 17.57 | 44.88 | 2,857 | Mining village. |
| Divide | 1.33 | 18.90 | 43.55 | 3,136 | |
| Sprague's Ranch | 3.64 | 22.54 | 39.91 | 2,950 | |
| Gravel Range | 2.96 | 25.50 | 36.95 | 2,987 | Hydraulic mines. |
| Big Flume | 1.62 | 27.12 | 35.33 | 2,982 | |
| Colfax | 1.95 | 29.07 | 33.38 | 3,022 | Toll-gate. |
| Crossing South Fork Tuolumne | 0.93 | 30.00 | 32.45 | 2,654 | Bridge. |
| Hardin's | 4.39 | 34.39 | 28.06 | 3,396 | Large ranch. |
| Crossing South Fork Tuolumne | 1.37 | 35.76 | 26.69 | | Bridge. |
| Hodgdon's | 5.34 | 41.10 | 21.35 | 4,506 | Bronson's meadow; stage station; wood, water, and forage; Hazel Green by trail, 2.88 miles. |
| Tuolumne Grove | 4.44 | 45.54 | 16.91 | 5,794 | Opposite the Dead Giant or Tunnel Tree. |
| Crane Flat | 1.00 | 46.54 | 15.91 | 6,054 | Public house. To Hazel Green by road, 4.76 miles. |
| Tamarack Flat | 5.07 | 51.61 | 10.84 | 6,234 | Wood and water; grass scarce. |
| Gentry's (deserted) | 2.81 | 54.42 | 8.03 | 5,627 | Old public house. |
| Junction Big Oak Flat and Coulterville roads. | 4.37 | 58.79 | 3.66 | | Yosemite Valley. |
| Barnard's Hotel | 3.66 | 62.45 | | 3,851 | Yosemite post-office. |

### *From Oakdale to Snelling, Cal.—Atlas-sheet No. 56 D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Oakdale. | From Snelling. | | |
| Oakdale | ........ | ........ | 31.46 | 149 | Terminus South Branch S. and C. R. R. |
| Fork road | 2.23 | 2.23 | 29.23 | 215 | |
| Martin's Ranch on Dry Creek | 7.38 | 9.61 | 21.85 | 127 | |
| Junction with river road near Roberts's Ferry. | 6.00 | 15.61 | 15.85 | 234 | |
| Roberts' Ferry | 1.14 | 16.75 | 14.71 | 184 | Tuolumne River. |
| Blodgett's Ranch | 3.81 | 20.56 | 10.90 | 216 | Old Morley Ranch; water and forage. |
| Fork road to Lagrange | 0.56 | 21.12 | 10.34 | 287 | Guide-board. |
| Cross-roads | 3.51 | 24.63 | 6.83 | .......... | |
| Fork roads | 2.50 | 27.13 | 4.33 | .......... | |
| Snelling Post-office | 4.33 | 31.46 | ........ | 252 | On Merced River. |

### *From Snelling to Merced, via Cox's Ferry, Cal.—Atlas-sheet No. 56 D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Snelling. | From Merced. | | |
| Snelling | ........ | ........ | 18.95 | 252 | At post-office, formerly county-seat. |
| Fork road to Ferry | 4.29 | 4.29 | 14.66 | .......... | Right-hand fork runs down river to Hopeton, &c. |
| Cox's Ferry | 1.70 | 5.99 | 12.96 | 250 | Merced River. |
| Cross-roads | 0.43 | 6.42 | 12.53 | .......... | Cross-road running along south side Merced River. |
| Top of hill | 1.67 | 8.09 | 10.86 | 394 | |
| Half-way House, or Waterloo Hotel | 4.51 | 12.60 | 6.35 | 215 | |
| Merced (at railroad crossing) | 6.35 | 18.95 | ........ | 171 | Seat Merced County. |

*From Snelling to Yosemite, Cal., via Coulterville Road.—Atlas-sheet No.* 56 *D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Snelling. | From Yosemite. | | |
| Snelling Post-office | ........ | ........ | 74.71 | 252 | On Merced River, formerly seat of Merced County. |
| Fork road to Merced Falls | 0.61 | 0.61 | 74.10 | .......... | |
| Fork road to Lagrange | 0.65 | 1.26 | 73.45 | .......... | |
| First bridge | 3.32 | 4.58 | 70.13 | .......... | |
| Second bridge | 0.76 | 5.34 | 69.37 | 267 | Dry Creek. |
| Crossing Merced Falls and Lagrange road. | 3.79 | 9.13 | 65.58 | 477 | |
| Junction Station | 1.26 | 10.39 | 64.32 | 578 | |
| Junction road from Lagrange | 3.02 | 13.41 | 61.30 | 916 | |
| Ranch | 2.51 | 15.92 | 58.79 | .......... | At junction of road from Merced Falls. |
| Toll Bridge | 1.88 | 17.80 | 56.91 | 993 | On North Piney Creek. |
| Junction road from Don Pedro's Bar. | 1.25 | 19.05 | 55.66 | .......... | |
| Granite Spring | 0.88 | 19.93 | 54.78 | 1,435 | Stage station. |
| Herbek's Ranch | 1.73 | 21.66 | 53.05 | 1,621 | Blacksmith shop. |
| Haigh's* | 2.93 | 24.59 | 50.12 | 1,807 | |
| Coulterville | 2.64 | 27.23 | 47.48 | 1,665 | |
| School-house, near Dexter's | 6.00 | 33.23 | 41.48 | 3,103 | Junction of road from Boneyard Ranch. |
| Dudley's | 1.58 | 34.81 | 39.90 | 2,959 | |
| Leave Smith Creek | 1.75 | 36.56 | 38.15 | 2,859 | |
| Strike fork of North Fork Merced. | 0.78 | 37.34 | 37.37 | 2,696 | |
| Bower Cave | 2.16 | 39.50 | 35.21 | 2,360 | Public house on North Fork Merced. |
| Stage Station | 3.23 | 42.73 | 31.98 | 3,218 | |
| Watering Trough | 4.00 | 46.73 | 27.98 | .......... | |
| Trail to Deer Flat turns off | 0.58 | 47.31 | 27.40 | 4,895 | |
| Hazel Green | 4.93 | 52.24 | 22.47 | 5,550 | |
| Forks road to Crane Flat | 0.36 | 52.60 | 22.19 | 5,502 | By left-hand road Hazel Green to Crane Flat, 4.76 miles. |
| Merced Grove Big Trees | 2.80 | 55.40 | 19.31 | .......... | |
| Big Meadows | 8.45 | 63.85 | 10.86 | 4,237 | Saw-mill and toll-gate. |
| Junction Trail from Hite's Cove | 4.59 | 68.44 | 6.27 | 3,352 | |
| Forks Coulterville and Big Oak Flat roads. | 2.61 | 71.05 | 3.66 | .......... | Yosemite Valley. |
| Barnard's Hotel | 3.66 | 74.71 | ........ | 3,851 | Yosemite post-office. |
| * By taking the left-hand road at Haigh's we have the following distances: | | | | | |
| Boneyard Ranch | 2.11 | ........ | ........ | 2,450 | Myers's store. |
| Road head of Bean Creek | 2.08 | ........ | ........ | 3,333 | |
| School-house | 4.09 | ........ | ........ | 3,103 | At junction with Coulterville stage-road, near Dexter's. |
| Total | 8.28 | ........ | ........ | .......... | Haigh's to junction with Coulterville road. |

*From Merced, Cal., to Mariposa, Cal.—Atlas-sheets Nos.* 56 *D and* 64 *B.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Merced. | From Mariposa. | | |
| Merced | ...... | ...... | 40.86 | 171 | Seat of Merced County. |
| Bear Creek Bridge | 1.16 | 1.16 | 39.70 | 168 | |
| Half-way House | 5.19 | 6.35 | 34.51 | 215 | Public house; grass in early summer; water; no wood. |
| Road forks to Snelling | 0.87 | 7.22 | 33.64 | ...... | |
| Lava Bed Station | 7.26 | 14.48 | 26.38 | 446 | |
| Griffith's Ranch | 3.63 | 18.11 | 22.75 | 473 | |
| Hornitos | 4.35 | 22.46 | 18.40 | 847 | Mining village. |
| Road forks to Indian Gulch | 1.52 | 23.98 | 16.88 | 898 | |
| Smith's Ranch | 2.44 | 26.42 | 14.44 | 1,047 | |
| Elkhorn Ranch | 0.50 | 26.92 | 13.94 | 1,049 | |
| Corbett's Ranch | 1.41 | 28.33 | 12.53 | 1,075 | Road forks to Cathey's Valley, 300 yards beyond ranch. |
| Toll-House | 1.81 | 30.14 | 10.72 | 1,598 | |
| Toll-House | 2.83 | 32.97 | 7.89 | 1,780 | |
| Summit | 1.92 | 34.89 | 5.97 | 2,169 | |
| Princeton | 0.73 | 35.62 | 5.24 | 2,104 | Mining village. |
| Foran's Store | 1.19 | 36.81 | 4.05 | 2,173 | |
| Summit | 1.16 | 37.97 | 2.89 | 2,416 | |
| Lewis' Ranch | 1.19 | 39.16 | 1.70 | 2,112 | |
| Sweetwater Road | 0.90 | 40.15 | 0.71 | 1,986 | |
| Mariposa | 0.36 | 40.51 | 0.35 | 1,971 | At Town Hall. |
| Do | 0.35 | 40.86 | ...... | 1,942 | At post-office. |

*From Mariposa, Cal., to Yosemite Valley, Cal.—Atlas-sheet No.* 56 *D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Mariposa. | From Yosemite Valley. | | |
| Mariposa | ...... | ...... | 53.09 | 1,942 | Seat of Mariposa County. |
| Mormon Bar | 1.89 | 1.89 | 51.20 | 1,630 | Mining village. |
| Sevastopol Flat | 2.76 | 4.65 | 48.44 | 2,210 | |
| Boot-jack Ranch | 0.90 | 5.55 | 47.54 | 2,107 | Road to Hite's Cove 200 yards beyond. |
| Thompson's | 2.61 | 8.16 | 44.93 | 2,114 | |
| Frye's | 0.64 | 8.80 | 44.29 | 2,281 | |
| Hale's | 2.18 | 10.98 | 42.11 | 2,739 | |
| Turner's (formerly Delong) | 1.11 | 12.09 | 41.00 | 2,741 | |
| Cold Spring | 4.36 | 16.45 | 36.64 | 3,126 | Stage station; wood, water and forage. |
| Summit | 5.24 | 21.69 | 31.40 | 5,605 | Divide between Chowchilla and South Fork Merced. |
| By Creek Bridge | 2.43 | 24.12 | 28.97 | 4,430 | |
| Clark's | 2.07 | 26.19 | 26.90 | 3,925 | Hotel and stage station; wood, water, pasturage and forage. |
| Eleven-mile Station | 10.76 | 36.95 | 16.14 | 5,567 | Wood and water. |
| Opposite Lower Bridge | 12.51 | 49.46 | 3.63 | 3,843 | New iron bridge over Merced. |
| Barnard's Hotel | 3.63 | 53.09 | ...... | 3,851 | Formerly Hutchings. Yosemite post-office. |

*From Barnard's Hotel to various points in the Yosemite Valley, Cal.—Atlas-sheet No. 56 D.*

### BARNARD TO SNOW'S HOTEL.

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Barnard's. | From Snow's. | | |
| Barnard's | | | 4.64 | 3,851 | At south end new bridge. |
| Illilouette Fork | 2.63 | 2.63 | 2.01 | | Bridge. |
| Register Rock | 0.62 | 3.25 | 1.39 | | Trail to foot of Vernal Fall. |
| Snow's Hotel | 1.39 | 4.64 | | 5,217 | Near foot of Nevada Fall. |

### BARNARD'S TO LOWER BRIDGE.

| | Between consecutive points. | From Barnard's. | From Snow's. | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| Barnard's | | | | 3,851 | Via south bank Merced River. |
| Black's | 0.77 | 0.77 | | | |
| Leidig's | 0.30 | 1.07 | | | |
| Lower Bridge | 2.56 | 3.63 | | 3,843 | |

### BARNARD'S TO FORKS COULTERVILLE AND OAK FLAT ROADS.

| | Between consecutive points. | From Barnard's. | From Snow's. | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| Barnard's | | | | | Via north side Merced River. |
| Forks Coulterville and Big Oak Flat road. | 3.82 | | | | |

### BARNARD'S TO FORKS COULTERVILLE AND OAK FLAT ROADS.

| | Between consecutive points. | From Barnard's. | From Snow's. | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| Barnard's | | | 3.66 | 3,851 | Via Leidig's and Middle Bridge. |
| Leidig's | 1.07 | 1.07 | | | |
| Forks Coulterville and Big Oak Flat road. | 2.59 | 3.66 | | | |

### BARNARD'S TO MIRROR LAKE.

| | Between consecutive points. | From Barnard's. | From Snow's. | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| Barnard's | | | | 3,851 | |
| Mirror Lake | 2.62 | | | 4,025 | |

### BARNARD'S TO EAGLE POINT.

| | Between consecutive points. | From Barnard's. | From Snow's. | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| Barnard's | | | | 3,851 | |
| Columbia Rock | 1.98 | 1.98 | | | |
| Foot Yosemite Falls | 0.69 | 2.67 | | | |
| Fork of Trails | 1.21 | 3.88 | | | Right hand trail to top of Yosemite Falls. |
| Eagle Meadows | 1.36 | 5.24 | | | |
| Eagle Point | 0.90 | 6.14 | | | |

### BARNARD'S TO GLACIER POINT.

| | Between consecutive points. | From Barnard's. | From Snow's. | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| Barnard's | | | 4.45 | | |
| Black's | 0.77 | 0.77 | 3.68 | | |
| Trail turns off | 0.27 | 1.04 | 3.41 | | |
| Union Point | 2.09 | 3.13 | 1.32 | | |
| Glacier Point | 1.32 | 4.45 | | | |

*From Barnard's Hotel to various points in the Yosemite Valley, California, &c.*—Continued.

### BARNARD'S TO SODA SPRINGS AND MOUNT LYELL VIA CATHEDRAL MEADOWS.

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | Barnard's. | Snow's. | | |
| Barnard's | ........ | ........ | ........ | 3,851 | |
| ·Register Rock | 3.25 | 3.25 | ........ | ........ | |
| Snow's | 1.39 | 4.64 | ........ | 5,217 | |
| Forks Trail | 0.92 | 5.56 | ........ | ........ | Trail to right, crosses Merced by bridge and runs to Sentinel Dome. |
| Fork Cloud Rest Trail | 3.52 | 9.08 | ........ | ........ | Cloud's Rest, by left-hand trail, about 2½ miles. |
| Top of Hill | 3.23 | 12.31 | ........ | 9,499 | |
| Divide Head of Cathedral Meadow | 5.20 | 17.51 | ........ | ........ | Near Cathedral Lakes. |
| Junction with Lake Tenaiya Trail | 4.14 | 21.65 | ........ | 8,575 | Soda Springs, $\frac{3}{10}$ mile up river on north bank. |
| Opposite junction Mount Lyell and Mount Dana Creeks | 1.60 | 23.25 | ........ | ........ | The old Mariposa and Mono trail runs up Mount Dana Creek. |
| Head of Tuolumne Meadows | 9.31 | 32.56 | ........ | 8,949 | Mount Lyell, about 5¼ miles via east side Lyell Creek. Good camping ground at first lake. |

*From Bower Cave, Cal., to Black's and Hennessy's Bridge, Cal.—Atlas-sheet No.* 56 *D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Bower Cave. | From Hennessy's. | | |
| Bower Cave | ........ | ........ | 21.53 | 2,360 | Station on Coulterville and Yosemite road. |
| Divide between North Fork Merced and Bull Creek. | 2.47 | 2.47 | 19.06 | 3,157 | |
| Black's | 1.91 | 4.38 | 17.15 | 2,621 | Ranch; wood, water, and forage. |
| Divide between Bonell Gulch and Merced Fork. | 3.62 | 8.00 | 13.53 | 3,342 | End of wagon-road. |
| Strike Merced | 3.17 | 11.17 | 10.36 | 1,197.1 | Trail follows up cañon of Merced, 40 feet above river. |
| Junction South Fork and Merced | 3.19 | 14.36 | 7.17 | 1,401 | Opposite mouth of South Fork, 50 feet above water. |
| Ferguson's Mill | 1.64 | 16.00 | 5.53 | 1,389 | 30 feet above water, estimated. |
| Hennessy's Bridge | 5.53 | 21.53 | ........ | 1,821 | Over South Fork; Hites Cove by trail, 7.24 miles. |

From Bower Cave to Black's, and the divide between Bonell Gulch and Merced the route is by wagon-road; thence to Hennessy's by trail.

*From Hite's Cove, Cal., to Yosemite Valley, Cal.—Atlas-sheet No.* 56 *D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Hite's Cove. | From Barnard's. | | |
| Hite's Cove | ...... | ......... | 22.17 | 1,601 | Mining village. |
| Divide between South Fork and Merced. | 1.59 | 1.59 | 20.58 | 3,342 | No camping place. |
| Hennessy's Bridge | 5.65 | 7.24 | 14.93 | 1,821 | Merced River; wood and grass. |
| Horton's River | 1.03 | 8.27 | 13.90 | 1,823 | Wood and grass. |
| Coulterville road | 5.65 | 13.92 | 8.25 | 3,352.4 | |
| Cascade Creek | 0.58 | 14.50 | 7.67 | .......... | Wood, water, and grass. |
| Junction Coulterville and Big Oak Flat roads. | 4.01 | 18.51 | 3.66 | .......... | Yosemite Valley. |
| Barnard's Hotel | 3.66 | 22.17 | ........ | 3,851 | Yosemite post-office. |

Route by trail until the Coulterville road is reached.

*From Fresno Flat, Cal., to Clark's (by new road), Cal.—Atlas-sheet No.* 56 *D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Fresno Flat. | From Clark's. | | |
| Fresno Flat | ....... | ........ | 23.39 | 2,192 | Station at post-office Mining Village. |
| Board Ranch | 12.99 | 12.99 | 10.40 | 4,639 | Stage station. |
| Summit | 3.60 | 16.59 | 6.80 | 5,109 | Divide between Fresno and Big Creeks. |
| Fork road to Big Trees | 3.33 | 19.92 | 3.47 | 5,062 | |
| Junction | 3.05 | 22.97 | 0.42 | 5,278 | With the Mariposa road. |
| Clark's | 0.42 | 23.39 | ........ | 3,925 | Big Tree Station post-office. |

This is a portion of the new route from Madera, on the Southern Pacific Railroad, to the Yosemite Valley, via Clark's. It has a very easy grade.

*From Fresno Flat, Cal., to Crane Valley, Cal.—Atlas-sheets Nos.* 56 *D and* 64 *B.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Fresno Flat. | From Crane Valley. | | |
| *Fresno Flat Post-office | ........ | .... | 7.91 | 2,192 | Mining village on Fresno River. |
| Taylor's Ranch | 1.47 | 1.47 | 6.44 | ...... | |
| Divide | 3.95 | 5.42 | 2.49 | 3,504 | Between Fresno River and North Fork San Joaquin. |
| Road | 0.66 | 6.08 | 1.83 | .......... | Road forks to left to saw-mill. |
| Crane Valley | 1.83 | 7.91 | ........ | 3,185 | Bridge near Sharpton's Ranch, on North Fork San Joaquin. |

* From Fresno Flat a road runs up the Fresno to the Madera saw-mill; distance 8.05 miles.

*From Snelling, Cal., to La Grange and Thompson's Ferry, Cal.—Atlas-sheet No.* 56 *D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Snelling. | From Thompson's. | | |
| Snelling Post-office | | | 14.38 | 252 | Formerly seat of Merced County, on Merced River. |
| Fork road to Merced Falls | 0.61 | 0.61 | 13.77 | | |
| Fork road to Coulterville | 0.65 | 1.26 | 13.12 | | |
| Crossing Dry Creek | 2.83 | 4.09 | 10.29 | 245 | |
| Cross-road | 3.28 | 7.37 | 7.01 | 313 | |
| Cross-road | 1.01 | 8.38 | 6.00 | | |
| Junction road to Roberts's Ferry | 0.83 | 9.21 | 5.17 | 410 | |
| Junction road from Merced Falls. | 2.37 | 11.58 | 2.80 | | |
| La Grange Post office | 0.12 | 11.70 | 2.68 | 222 | Mining village on Merced River (formerly French Bar). |
| Thompson's Ferry | 2.68 | 14.38 | | 188 | Over Merced River; formerly at Lagrange. |

*From Lagrange, Cal., to Merced Falls and Cunningham's road (on old Fort Miller road), Cal.—Atlas-sheet No.* 56 *D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From La Grange. | From Cunningham's. | | |
| Lagrange | | | 30.63 | 222 | Mining town on Tuolumne River. |
| Fork road to Snelling | 0.12 | .12 | 30.51 | | Running south. |
| Fork Coulterville road | 2.95 | 3.07 | 27.56 | 443 | Running east. |
| County Corner-stone | 1.80 | 4.87 | 25.76 | 590 | Cor. of Stanislaus, Tuolumne, Merced, and Mariposa Counties. |
| Crossing Coulterville and Snelling road. | 0.94 | 5.81 | 24.82 | 572 | |
| Sheep Ranch | 3.38 | 9.19 | 21.44 | | |
| Fork roads | 4.07 | 13.26 | 17.37 | 463 | |
| Merced Falls | 0.94 | 14.20 | 16.43 | 360 | Manufacturing and agricultural village. |
| Ferry | 0.49 | 14.69 | 15.94 | 369 | Road turning up river runs to ranches and Hornitos. |
| Fork road to Hornitos | 2.85 | 17.54 | 13.09 | 471 | Main road. |
| Griffith's Ranch | 2.14 | 19.68 | 10.95 | 473 | Hornitos, 4.35 miles. |
| Junction Roads at Butte | 3.32 | 23.00 | 7.63 | | Road comes in from south. |
| Crossing Burns's Creek | 1.90 | 24.90 | 5.73 | 269 | Water in spring and early summer. |
| Junction Road for Indian Gulch. | 0.90 | 25.80 | 4.83 | | Indian Gulch 5.56 miles. |
| Gray's Ranch | 0.36 | 26.16 | 4.47 | 307 | Wood, water, and grass; sheep ranch. |
| Bear Creek Crossing | 1.94 | 28.10 | 2.53 | 350 | Water in spring and summer. |
| Merced and Mariposa road | 1.26 | 29.36 | 1.27 | 365 | |
| Cunningham's Ranch | 1.27 | 30.63 | | 387 | South of Miles Creek, on old Fort Miller road. |

*From Mariposa, Cal., to Lewis Ranch, Cal., via Moore Hill Road, Atlas-sheet No.* 56 *D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Mariposa. | From Lewis Ranch. | | |
| **Mariposa Post-office** | ........ | ........ | 15.31 | 1,932 | Mining town; seat of Mariposa County. |
| Mormon Bar | 1.89 | 1.89 | 13.42 | 1,630 | Mining village. |
| Bridgeport | 4.20 | 6.09 | 9.22 | 1,357 | Old mining village. |
| Summit | 1.00 | 7.09 | 8.22 | 1,588 | Moore Hill. |
| Mariposa Creek Crossing | 1.55 | 8.64 | 6.67 | 1,142 | |
| Lewis Ranch | 6.67 | 15.31 | ........ | 966 | Wood, water, forage or pasturage. |

*From Mariposa, Cal., to Bear Valley, Cal., Atlas-sheet No.* 56 *D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Mariposa. | From Bear Valley. | | |
| **Mariposa Post-office** | ........ | ........ | 11.80 | 1,932 | Seat of Mariposa County. |
| Princeton | 5.24 | 5.24 | 6.56 | 2,104 | Mining village. |
| Forks (take right-hand) | 0.36 | 5.60 | 6.20 | .......... | Left-hand road to Hornitos, 12.10 miles. |
| **Bear Valley Post-office** | 6.20 | 11.80 | ........ | 2,087 | Mining village. |

*From Hornitos to Merced, Cal., via Indian Gulch and Old Fort Miller road.—Atlas-sheet No.* 56 *D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Hornitos. | From Merced. | | |
| **Hornitos** | ........ | ........ | 30.67 | .......... | Mining village. |
| Leave Mariposa road | 1.52 | 1.52 | 29.15 | 898 | Mariposa road forks to left. |
| Cut-off from Mariposa road | 1.64 | 3.16 | 27.51 | 1,058 | |
| Road to Cathey Valley | 2.27 | 5.43 | 25.24 | .......... | |
| Indian Gulch | 0.27 | 5.70 | 24.97 | 951.4 | Mining village. |
| Old Fort Miller road | 5.56 | 11.26 | 19.41 | .......... | |
| Gray's Ranch | 0.36 | 11.62 | 19.05 | 307 | Wood, water, and grass. |
| Bear Creek Crossing | 1.94 | 13.56 | 17.11 | 350 | |
| Merced and Cathey's Valley road | 1.26 | 14.82 | 15.85 | 373 | Old Fort Miller road crosses Cathey's Valley and Merced road. |
| County Hospital | 11.97 | 26.79 | 3.88 | .......... | |
| **Merced (at railroad crossing)** | 3.88 | 30.67 | ........ | 171 | Seat Merced County. |

*From Hornitos to Bear Valley, Cal.—Atlas-sheet No. 56 D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Hornitos. | From Bear Valley. | | |
| Hornitos Hotel | ........ | ........ | 10.79 | 847 | Mining village. |
| Washington Quartz Mills | 2.48 | 2.48 | 8.31 | 1,032 | |
| Fork Road to Simmons's Ranch | 2.90 | 5.38 | 5.41 | 1,387 | |
| * Blackmore's Ranch | 1.85 | 7.23 | 3.56 | 2,230 | Road forks to left to Hunter's Valley and ranches. |
| Divide | 1.52 | 8.75 | 2.04 | 2,755 | Between Hunter's Valley and Bear Valley. |
| Bear Valley | 2.04 | 10.79 | ........ | 2,087 | At Oso House. |

* Road to left runs to ranches on Cotton Creek, Hunter's Valley, and to old mining village of Chemisal (deserted), distant 3.95 miles.

*From Hornitos to Redman's Ranch, Cathey's Valley, Cal.—Atlas-sheet No. 56 D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Hornitos. | From Redman's Ranch. | | |
| Hornitos Hotel | ........ | ........ | 12.82 | 847 | Mining town. |
| Corbett's Ranch | 5.87 | 5.87 | 6.95 | 1,075 | Forks Cathey's Valley and Mariposa roads, 300 yards beyond. |
| Fitzhugh's Ranch | 3.77 | 9.64 | 3.18 | 1,162 | Do. |
| Church and school-house | 0.97 | 10.61 | 2.21 | 1,252 | Valley. |
| Cathey's Ranch | 1.33 | 11.94 | .88 | 1,260 | Wood, water, and forage. |
| Redman's Ranch | 0.88 | 12.82 | ........ | 1,181 | Do. |

*From Cathey's Valley to Merced, Cal.—Atlas-sheet No. 56 D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Cathey's. | From Merced. | | |
| Redman's | ........ | ........ | 25.53 | 1,180 | Wood, water, and forage. |
| Crossing Millerton road | 9.68 | 9.68 | 15.85 | 313 | |
| School-House | 10.28 | 19.96 | 5.57 | 182 | |
| Upton's | 1.03 | 20.99 | 4.54 | .......... | Water and forage. |
| County Hospital | 0.66 | 21.65 | 3.38 | .......... | |
| Taylor's | 1.02 | 22.67 | 2.86 | .......... | Do. |
| Bear Creek Bridge | 1.69 | 24.36 | 1.17 | 168 | |
| Merced (at railroad crossing) | 1.17 | 25.53 | ........ | 171 | Seat of Merced County on Southern Pacific Railroad. |

### *From Thompson's Ferry to Crimea House, Cal.—Atlas-sheet No.* 56 *D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Thompson's Ferry. | From Crimea House. | | |
| Thompson's Ferry | ........ | ........ | 18.41 | 188 | — miles below Lagrange, on Tuolumne River; , wood, water, and grass. |
| Junction old Lagrange and Knight's Ferry road. | 5.17 | 5.17 | 13.24 | 319 | |
| Bosang's road on Dry Creek | 0.71 | 5.88 | 12.53 | .......... | |
| Gallup's road | 0.90 | 6.78 | 11.63 | 280 | |
| Junction Lagrange freight road | 1.40 | 8.18 | 10.23 | 259 | At Stone Fence, ½ mile north of Armstrong's Ranch; main road keeps on to Knight's Ferry; right-hand road to Crimea House. |
| Drew's Ranch | 6.20 | 14.38 | 4.03 | 1,090 | |
| Divide | 0.63 | 15.01 | 3.40 | 1,384 | |
| Crimea House | 3.40 | 18.41 | ........ | 1,221 | Public house; wood, water, and forage. |

This route is by the first road to right below Thompson's Ferry. Between the river and the old Lagrange and Knight's Ferry road the road is at present a natural grade, only suitable for light wagons. Freight teams take the next right-hand road, and strike the Lagrange and Knight's Ferry road 0.5 mile beyond Armstrong's Ranch.

### *From Knight's Ferry Bridge to Chinese Camp, Cal.—Atlas-sheet No.* 56 *B and D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | |
|---|---|---|---|---|---|
| | Between consecutive points. | From Knight's Ferry Bridge. | From Chinese Camp. | | |
| Knight's Ferry Bridge | ........ | ........ | 14.75 | 180 | Over Stanislaus, above Knight's Ferry. |
| Crabtrees | 4.79 | 4.79 | 9.96 | 934 | Ranch and spring. |
| Keystone House | 4.15 | 8.94 | 5.81 | 1,093 | Public house at cross-roads. |
| Crimea House | 1.69 | 10.63 | 4.12 | 1,221 | Public house; wood, water, and forage. |
| Taylor's Ranch | 2.73 | 13.36 | 1.39 | 1,047 | Public house on Six-bit Gulch. |
| Chinese Camp Post Office | 1.39 | 14.75 | ........ | 1,299 | Mining town. |

*From Knight's Ferry Bridge to Copperopolis, Cal., via Byrnes's Ferry.—Atlas-sheet No. 56 C and 56 D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | |
|---|---|---|---|---|---|
| | Between consecutive points. | From Knight's Ferry Bridge. | From Copperopolis. | | |
| Knight's Ferry Bridge | ........ | ........ | 25. 91 | 180 | On Stanislaus, above town of Knight's Ferry. |
| Buena Vista | 0. 33 | . 33 | 25. 58 | 323 | Store. |
| Ranch and spring | 2. 92 | 3. 25 | 22. 66 | ........ | |
| Crabtrees | 1. 54 | 4. 79 | 26. 12 | 934 | |
| Divide | 1. 00 | 5. 79 | 21. 12 | 1, 117 | |
| Fork roads | 2. 04 | 7. 83 | 18. 08 | ........ | Lagrange road, to right. |
| Keystone House | 1. 11 | 8. 94 | 16. 97 | 1, 093 | Public house cross-roads. |
| New York Tent | 4. 05 | 12. 90 | 12. 92 | 1, 143 | Cross-road. |
| Fork road to Sonora | 0. 46 | 13. 45 | 12 46 | 1, 117 | Via Rawhide Camp. |
| Byrnes's Ferry | 4. 86 | 18. 31 | 7. 60 | 380 | Toll-bridge over Stanislaus. |
| School-House | 2. 57 | 20. 88 | 5. 03 | 412 | |
| Copperopolis Post Office | 5. 03 | 25. 91 | ........ | 1, 015 | Old mining town. |

*From Roberts' Ferry to Knight's Ferry Bridge, Cal.—Atlas-sheets Nos.* 56 *C and* 56 *D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Roberts' Ferry. | From Knight's Ferry Bridge. | | |
| Roberts' Ferry | ........ | ........ | 24. 09 | 184 | Tuolumne River. |
| Fork of roads | 0. 70 | . 70 | 23. 39 | 223 | |
| Large Ranch | 5. 66 | 6. 36 | 17. 73 | 230 | |
| Junction Lagrange and Knight's Ferry Bridge. | 1. 76 | 8. 12 | 15 97 | 251 | |
| Divide between Tuolumne and Stanislaus. | 4. 58 | 12. 70 | 11. 39 | 518 | |
| Williams' Ranch | 1. 24 | 13. 94 | 10. 15 | 345 | |
| Buena Vista | 1. 54 | 15. 48 | 8. 61 | 323 | Flagstaff at store. |
| Knight's Ferry Bridge | 0. 33 | 15. 81 | ........ | 180 | Over Stanislaus, above Knight's Ferry. |

*From New York Tent to Sonora, Cal.—Atlas-sheet No.* 56 *D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From New York Tent. | From Sonora. | | |
| New York Tent | ........ | ........ | 9. 45 | 1, 143 | Cross-roads. |
| Fork road to Byrnes' Ferry | 0. 46 | . 46 | 8. 99 | 1, 117 | |
| Table Mountain Divide | 0. 42 | . 88 | 8. 57 | 1, 198 | |
| Ranch and creek | 1. 31 | 2. 19 | 7. 26 | 1, 113 | |
| Divide between creeks | 0. 96 | 3. 15 | 6. 30 | 1, 320 | |
| Rawhide Camp | 4. 00 | 7. 15 | 2. 30 | 1, 556 | At store. |
| Fork road to Tuttletown | 2. 30 | 9. 45 | ........ | 1, 566 | |
| Shaw's Flat | 3. 22 | ........ | ........ | 2, 036 | |
| Sonora Post Office | 2. 18 | ........ | ........ | 1, 816 | |

### *From Sonora to Jacksonville, Cal.—Atlas-sheet No.* 56 *D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Sonora. | From Jacksonville. | | |
| Sonora Post Office | | | 12.43 | 1,816 | Town. |
| McQuaid's | 0.62 | .62 | 11.81 | 1,888 | Sonora and Mono road to left. |
| Junction road to Chinese Camp | 0.73 | 1.35 | 11.08 | 1,775 | |
| Kincaid's Flat | 1.60 | 2.95 | 9.48 | 1,589 | |
| Amy's Ranch | 1.53 | 4.48 | 7.95 | 1,494 | |
| Flume | 1.15 | 5.63 | 6.80 | 1,667 | |
| Cross-roads | 1.29 | 6.92 | 5.51 | 1,565 | |
| Twist's Ranch | 2.23 | 9.15 | 3.28 | 1,121 | |
| Jacksonville | 3.28 | 12.43 | | 602 | At hotel. |

### *From Bridgeport to Mountain House, Cal., via Cañon of West Walker and Coleville.—Atlas-sheets No.* 57 *A and* 56 *B.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Bridgeport. | From Mountain House. | | |
| Bridgeport Post Office | | | 50.57 | 6,423 | Seat of Mono County. |
| Hot Springs | 14.30 | 14.30 | 36.27 | 7,384 | Stage station; wood, water and forage, or pasturage. |
| *East Branch of West Walker | 3.29 | 17.59 | 32.98 | | Coleville road leaves Sonora and Mono roads here and runs south. |
| Junction of East Branch with West Walker. | 2.85 | 20.44 | 30.13 | | Road enters cañon of West Walker. |
| Ranch | 10.05 | 30.49 | 20.08 | | At mouth of West Walker Cañon. |
| Road to Little Antelope | 3.75 | 34.24 | 16.33 | | Road turns up cañon to left. |
| Coleville (blacksmith shop) | 2.00 | 36.24 | 14.33 | 5,190 | Agricultural Village, head of Antelope Valley. |
| †School-House | 5.00 | 41.24 | 9.33 | | Forks of road. |
| Carson and Aurora stage-road | 8.50 | 49.74 | .83 | | 0.83 miles south of Mountain House and 7.79 miles west of Walker River post-office. |
| Mountain House | 0.83 | 50.57 | | 5,641 | Stage station on Carson and Aurora road; water and forage. |

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*The road down the cañon of the West Walker to Coleville was opened in the fall of 1878. It has a fine natural grade.

†By the right-hand road the Carson and Aurora stage-road may be reached in 9.5 miles, or 0.88 miles west of Hoye's, making total distance from Coleville to Hoye's Store 10.38 miles, and Coleville to Mountain House 22.24 miles. For distance from Mountain House to Carson, Nev., see page 64, Report 1878.

*From Bridgeport, Cal., to Mountain House, Nev., via East Walker River Road.—Atlas-sheets Nos.* 57 *A and* 56 *B.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Bridgeport. | From Mountain House. | | |
| Bridgeport Post Office | | | 55.27 | 6,423 | Seat of Mono County, on the East Walker River; water and pasturage. |
| Toll-House | 8.54 | 8.54 | 46.73 | | |
| Frying Pan Creek | 3.48 | 12.02 | 43.25 | | |
| Boundary Stake | 0.96 | 12.98 | 42.29 | | California and Nevada boundary. |
| Carson and Aurora stage-road | 2.46 | 15.44 | 39.83 | | |
| Sweetwater Post Office | 1.28 | 16.72 | 38.55 | | Store. |
| Williams' Station | 2.83 | 19.55 | 35.72 | | Stage station; wood, water, and forage. |
| Ranch | 6.85 | 26.40 | 28.87 | | Cattle ranch. |
| Sulphur Spring Station | 4.82 | 31.22 | 24.05 | | Stage station; wood, water, and forage. |
| Matthews' Ranch | 7.86 | 39.08 | 16.19 | | Desert Creek, stage-station; water and forage. |
| *Road to Wellington's | 3.75 | 42.83 | 12.44 | | Stage station on West Walker River, 0.46 miles distant. |
| †Hoye's Store | 3.82 | 46.65 | 8.62 | | Walker River post-office; stage station; wood, water, and forage. |
| Fork of road to Coleville | 0.88 | 47.53 | 7.74 | | Road forks to the left and runs up west side Antelope Valley. |
| Mountain House | 7.74 | 55.27 | | 5,641 | |

* Wellington's is off the main road 0.46 mile. Total, Matthews' to Wellington's, 4.21 miles; Wellington's to Hoye's, 3.80 miles.

† Hoye's Store to Coleville, via wagon-road on east side Antelope Valley, is little traveled. Hoye's Store to Coleville, via west side Antelope Valley (main route), 10.38 miles.

*From Sonora to San Andreas, Cal.—Atlas-sheets Nos.* 56 *D and* 56 *C.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Sonora. | From San Andreas. | | |
| Sonora | | | 28.09 | 1,816 | At post-office; seat of Tuolumne County. |
| Shaw's Flat | 2.18 | 2.18 | 26.01 | 2,036 | Mining village. |
| Tuttletown | 4.30 | 6.48 | 21.61 | 1,321 | Do. |
| Robertson's Ferry | 2.16 | 8.64 | 19.45 | 819 | Stanislaus River. |
| Angel's | 6.57 | 15.21 | 12.88 | | Mining town. |
| San Andreas | 12.88 | 28.09 | | 1,033 | Seat of Calaveras County. |

### *From Sonora to Milton, Cal.—Atlas-sheets Nos.* 56 *D and* 56 *C.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Sonora. | From Milton. | | |
| Sonora | ........ | ........ | 34.65 | 1,816 | At the post-office. |
| Shaw's Flat | 2.18 | 2.18 | 32.47 | 2,036 | |
| Illinois Ranch | 2.25 | 4.43 | 30.22 | 1,759 | Wood, water, and forage. |
| Tuttletown | 2.05 | 6.48 | 28.17 | 1,321 | Mining village. |
| Forks of road | 1.23 | 7.71 | 26.94 | ......... | Robertson's Ferry, 1 mile by right-hand road. |
| Reynolds's Ferry | 4.39 | 12.10 | 22.55 | 543 | South Fork of the Stanislaus. |
| Copperopolis | 7.72 | 19.82 | 14.83 | 1,015 | Mining town. |
| Reservoir House | 8.70 | 28.52 | 6.13 | 1,013 | Stage station; wood, water and forage. |
| Toll-house | 1.59 | 30.11 | 4.54 | 777 | |
| Milton | 4.54 | 34.65 | ........ | 376 | At the railroad depot; terminus Stockton and Copperpolis Railroad. |

Stage-route between Milton and Sonora.

### *From Sonora to Northrup's, Cal.—Atlas-sheet No.* 56 *D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Sonora. | From Northrup's. | | |
| Sonora | ...... | ...... | 14.49 | 1,816 | At post-office. |
| McQuaid's | 0.62 | .62 | 13.87 | 1,888 | Forage, &c.; public house; road forks to Jacksonville. |
| Sullivan Creek | 1.97 | 2.59 | 11.90 | .......... | Ranch. |
| Road to Phenix Reservoirs | 0.55 | 3.14 | 11.35 | .......... | Do. |
| School-House | 1.69 | 4.83 | 9.66 | .......... | |
| Soulsbyville House | 1.43 | 6.26 | 8.23 | .......... | Public house. |
| Crawford's | 1.79 | 8.05 | 6.44 | .......... | Ranch. |
| Old Toll-house | 3.06 | 11.11 | 3.38 | .......... | Do. |
| Baxter's | 2.13 | 13.24 | 1.25 | 4,115 | Mining camp, Confidence mine; gold, quartz. |
| Northrup's (Excelsior Hotel) | 1.25 | 14.49 | ........ | 4,519 | Stage station and toll-house; wood, water, and forage. |

This is a portion of the Sonora and Mono turnpike-road from Sonora to Bridgeport, Cal. Road kept in good order. Main stage-route between Sonora and the Bodie and Aurora mines.

*From Northrup's to Bridgeport, Cal.—Atlas-sheets Nos.* 56 *B*, 56 *D, and* 57 *A.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Northrup's. | From Bridgeport. | | |
| Northrup's | ........ | ........ | 84.74 | 4,519 | Post-office. |
| Bradford's Saw-Mill | 4.91 | 4.91 | 79.83 | .......... | Trail. |
| Ranch | 1.84 | 6.75 | 77.99 | .......... | Wood, water, and grass. |
| Bald Mountain | 2.78 | 9.53 | 75.21 | 5,829 | The altitude is at bare point on top of ridge. |
| Cold Spring | 2.85 | 12.38 | 72.36 | .......... | Good spring south of road. |
| Strawberry | 3.55 | 15.93 | 68.81 | 5,238 | Stage station; wood, water, and forage. |
| Summit | 2.27 | 18.20 | 66.55 | 6,352 | Divide between the South and Middle Forks of the Stanislaus. |
| Cow Creek | 1.90 | 20.10 | 64.64 | 5,905 | Ranch; main branch Cow Creek ½ mile beyond. |
| Lilly Creek | 2.17 | 22.27 | 62.47 | .......... | |
| Cascade Creek | 2.62 | 24.89 | 59.85 | 6,272 | |
| Mill Creek | 2.58 | 27.47 | 57.27 | 6,467 | Bridge. |
| Niagara Creek | 2.53 | 30.02 | 54.72 | 6,690 | Do. |
| Eagle Creek | 7.73 | 37.75 | 46.99 | .......... | Bridge; road crosses Stanislaus 0.4 miles beyond. |
| Eureka Valley | 2.90 | 40.65 | 44.09 | 5,957 | Stage station (formerly Hay's). |
| Hog's Pass | 3.00 | 43.65 | 41.09 | .......... | Road cut through granite bowlder. |
| Summit | 8.20 | 51.85 | 32.89 | 9,660 | Sonora Pass, crest of Sierra Nevada. |
| Leavitt's | 7.59 | 59.44 | 25.30 | .......... | Stage station and horse ranch. |
| Pickle's | 3.42 | 62.86 | 21.88 | .......... | Horse ranch. |
| West Walker River | 1.89 | 64.75 | 19.99 | .......... | Bridge; wood and water; grass scarce. |
| East Branch West Walker | 2.40 | 61.15 | 17.59 | 7,019 | Ford; road from Coleville; wood, water, and grass. |
| Hot Springs | 3.29 | 70.44 | 14.30 | 7,384 | Stage station; forage and pasturage. |
| Rickey's | 7.32 | 77.76 | 6.98 | .......... | Hay and cattle ranch. |
| Saw-Mill | 1.98 | 79.74 | 5.00 | .......... | Formerly Yaney's. |
| Bridgeport | 5.00 | 84.74 | ....... | 6,423 | Seat Mono County; pasturage and forage. |

Sonora and Mono stage-road, being part of the through stage-route from Milton, on Stockton and Copperopolis Railroad, to the Bodie and Aurora mining district.

*From Carson, Nev., to Volcano, Cal., via Amador and Nevada wagon-road.—Atlas-sheets Nos. 47 D and 56 B.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Carson. | From Volcano. | | |
| Carson | ........ | ........ | 97.00 | 4,660 | At the capitol. |
| Woodford's | 30.87 | 30.87 | 66.13 | 5,676 | Stage station; mouth of cañon of West Fork Carson River. |
| *Williams' Ranch | 13.11 | 43.98 | 53.02 | 7,757 | Wood, water, and grass. |
| Carson Pass | 1.81 | 45.79 | 51.21 | 8,634 | Crest of Sierra Nevada. |
| Caple's Ranch | 3.68 | 49.47 | 47.53 | 7,780 | Clear Lakes; wood, water, and grass. |
| Silver Lake Hotel | 7.37 | 56.84 | 40.16 | 7,174 | Public house; wood, water, and forage. |
| Tragedy Spring | 3.00 | 59.84 | 37.16 | 7,989 | Wood, water, and grass. |
| † Road forks to Pleasant Valley | 4.48 | 64.32 | 32.68 | .......... | |
| Corral Flat | 0.78 | 65.10 | 31.90 | .......... | Wood and water; grass scarce. |
| Peddler's Hill | 5.66 | 70.76 | 26.24 | 6,831 | Wood, spring (runs dry in summer). |
| Cold Spring | 4.39 | 75.15 | 21.85 | ...... | Wood and water. |
| Mud Spring | 0.39 | 75.54 | 21.46 | 5,973 | Do. |
| Ham's Station | 2.08 | 77.62 | 19.38 | 5,439 | Public house; wood, water, and forage. |
| Wiley's Station | 3.77 | 81.39 | 15.61 | 5,027 | Do. |
| Antelope Spring | 3.20 | 84.59 | 12.41 | 4,272 | Do. |
| Forks of road | 0.32 | 84.91 | 12.09 | .......... | Left fork known as Antelope and Pine Grove Turnpike. |
| Horsley's Station | 1.34 | 86.25 | 10.75 | 3,860 | Public house; formerly French Camp; wood, water, and forage. |
| Myers's Station | 2.23 | 88.48 | 8.52 | 3,750 | Public house; formerly Thorp's; wood; water, and forage. |
| ‡ Foster's Station | 2.17 | 90.65 | 6.35 | 3,265 | Public house; wood, water, and forage. |
| § Denser's Station | 3.07 | 93.72 | 3.28 | 2,922 | Public house; wood, water and forage. |
| Volcano | 3.28 | 97.00 | ........ | 2,075 | Mining town. |

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*At Williams' Ranch there is a branch road to Hermit Valley, on the Big Tree road; distance, 16.71 miles. From this branch road a road forks to the right and runs to Summit City (abandoned) and Blue Lakes.

† At this point a road forks to the right, running to Leek Spring, Pleasant Valley, and Newtown. (See Report of 1878, p. 61.)

‡ Right-hand road to Fiddletown.

§ Right-hand road to Sutter.

*From Carson, Nev., to Murphy's, Cal., via Silver Mountain City and Big Tree road.—Atlas-sheets Nos.* 47 *D and* 56 *B.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Carson. | From Murphy's. | | |
| Carson | ........ | ........ | 110.37 | 4,660 | State capitol. |
| Woodford's | 30.87 | 30.87 | 79.50 | 5,676 | Stage station mouth cañon west Fork Carson. |
| Markleeville | 6.63 | 37.50 | 72.87 | 5,525 | Seat of Alpine County. |
| Bridge and Old Toll-house | 1.61 | 39.11 | 71.26 | .......... | |
| Mount Bullion Toll-house | 3.74 | 42.85 | 67.52 | .......... | Road to Monitor forks to the west. |
| Centreville | 2.55 | 45.40 | 64.97 | .......... | Abandoned mining village, opposite mouth Wolf Creek. |
| Silver Mountain City | 3.26 | 48.66 | 61.71 | 6,446 | Mining town; wood, water and forage. |
| First Summit | 6.23 | 54.89 | 55.48 | .......... | Divide between drainage basins of the Carson and Mokelumne Rivers. |
| Hermit Valley | 5.47 | 60.36 | 50.01 | 7,039 | Wood, water, and forage, or pasturage. |
| Second Summit | 2.71 | 63.07 | 47.30 | 8,157 | Divide between drainage basins of Mokelumne and Stanislaus Rivers. |
| Silver Valley | 5.74 | 68.81 | 41.56 | .......... | Wood, water, and grass. |
| Blood's Station | 3.74 | 72.55 | 37.82 | 6,979 | Toll-house and cattle ranch; wood, water, and forage or pasturage. |
| Onion Valley | 2.33 | 74.88 | 35.49 | .......... | Wood and water; grass poor. |
| *Big Meadow Creek | 3.01 | 77.89 | 32.48 | 6,464 | Wood, water, and grass; bridge. |
| Black Springs | 5.70 | 83.59 | 26.78 | 6,485 | Wood and water; grass scarce. |
| Gardener's Station | 8.54 | 92.13 | 28.24 | .......... | Wood, water, and forage or pasturage. |
| Big Trees of Calaveras | 2.82 | 94.95 | 15.42 | 4,730 | Hotel; wood, water, and forage. |
| Half-Way House | 7.81 | 102.26 | 8.11 | 3,358 | Inn; wood, water, and forage. |
| Murphy's mining village | 8.11 | 110.37 | ........ | 2,195 | Blacksmith's shop at cross-roads; post-office 0.33 mile west. |

Good mountain road.

* A little beyond this creek a road to West Point turns off. It is used principally by sheep and cattle herders. Distance as follows: Big Meadow Creek to Big Meadow Ranch, 1.39 miles; Big Meadow Ranch to Folsom and Hall's, at Hunter's Flat, 16.17 miles; Folsom and Hall's to Lillie's Ranch, 3.71 miles; Lillie's to West Point, 6.34 miles; total distance, 21.61 miles.

### *From Calaveras Big Tree Grove to Murphy's, Cal.—Atlas-sheet No.* 56 *B.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Calaveras Grove. | From Half-Way House. | | |
| *Calaveras Grove | | | 7.60 | 4,730 | At the hotel. |
| Fourteen-mile House | 1.21 | 1.21 | 6.39 | | |
| West Point road | 1.38 | 2.59 | 5.01 | | Road to West Point via Railroad Flat. |
| Ranch | 2.16 | 4.75 | 2.85 | | Wood, water, and forage. |
| Half-Way House | 2.85 | 7.60 | | 3,358 | Wood, water, and forage; stage station. |
| †Calaveras Grove | | | 7.31 | 4,730 | Hotel; wood, water, pasturage, and forage. |
| Junction | 2.10 | 2.10 | 5.21 | | |
| Moran's Ranch | 1.04 | 3.14 | 4.17 | 3,984 | Wood, water, pasturage, and forage. |
| Flanders' Ranch | 1.30 | 4.44 | 2.87 | | |
| Half-Way House | 2.87 | 7.31 | | | Stage station. |
| Half-Way House | | | | 3,358 | |
| Murphy's | 8.11 | | | 2,195 | At blacksmith's shop, fork of Altaville and Sonora roads, ½ mile northeast of post-office. |

* Via upper road. † Via lower or Moran road. Both routes good.

### *From Murphy's to Sonora, Cal.—Atlas-sheets Nos.* 56 *B and* 56 *D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Murphy's. | From Sonora. | | |
| Murphy's | | | 18.24 | 2,195 | Mining village; at blacksmith shop. |
| Douglas Flat | 1.67 | 1.67 | 16.57 | | Do. |
| Vallecito | 2.49 | 4.16 | 14.08 | 1,748 | City post-office; mining village. |
| Trail to Natural Bridge | 3.32 | 7.48 | 10.76 | | Natural bridges on Coyote Creek; ½ mile. |
| Parrott's (formerly Pandola) Ferry | 2.27 | 9.75 | 8.49 | 834 | South Fork Stanislaus. |
| Gold Spring | 3.17 | 12.92 | 5.32 | 2,014 | Old mining village; wood, water, and forage. |
| Columbia Post Office | 1.15 | 14.07 | 4.17 | 2,157 | Mining town. |
| Donglasville | 1.54 | 15.61 | 2.63 | | Saloon. |
| Brown's Flat | 0.89 | 16.50 | 1.74 | 1,964 | Mining town. |
| Sonora | 1.74 | 18.24 | | 1,816 | At post-office. |

### *From West Point to Calaveras Big Trees, Cal.—Atlas-sheet No. 56 B.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From West Point. | From Calaveras. | | |
| West Point | | | 23.55 | 2,749 | At post-office. |
| Middle Fork Mokelumne | 1.07 | 1.07 | 22.48 | 2,436 | Bridge. |
| Fork of road | 1.68 | 2.75 | 20.80 | | To Blue Mount City. |
| Licking Fork Mokelumne | 1.37 | 4.12 | 19.43 | 2,196 | |
| South Fork Mokelumne | 0.72 | 4.84 | 18.71 | | |
| Railroad Flat | 1.49 | 6.33 | 17.22 | 2,606 | At post-office. |
| Forks of road | 0.30 | 6.63 | 16.92 | | Right-hand road to McCarty's mill. |
| Sheep Herder's Cabin | 5.59 | 12.22 | 11.33 | | Wood, water, and grass in early summer. |
| Summit | 5.05 | 17.27 | 6.28 | 4,658 | |
| San Antonio Creek | 3.12 | 20.39 | 3.16 | 3,848 | Crossing near Dunbar's old saw-mill. |
| Big Tree road | 0.57 | 20.96 | 2.59 | | |
| Fourteen-Mile House | 1.38 | 22.34 | 1.21 | | |
| Big Tree Hotel | 1.21 | 23.55 | | 4,730 | Calaveras Grove. |

### *From Antelope Springs to Volcano, Cal., via Antelope and Pine Grove Turnpike.—Atlas-sheet No. 56 B.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Antelope Springs. | From Volcano. | | |
| Antelope Springs | | | 14.62 | 4,272 | |
| Forks of the road | 0.32 | 0.32 | 14.30 | | Right-hand road to Drytown, Fiddletown, &c. |
| Ranch | 5.24 | 5.56 | 9.06 | | |
| Ranch | 1.27 | 6.83 | 7.79 | | Watering-trough, wood, and and forage. |
| Harkness Ranch | 1.00 | 7.83 | 6.79 | | |
| *Road forks to West Point | 1.39 | 9.22 | 5.40 | | |
| †Foster's Ranch | 0.68 | 9.90 | 4.70 | 2,881 | Wood, water, and forage. |
| Forks of the road | 1.84 | 11.74 | 2.88 | | Road to Volcano forks to the right from Antelope and Pine Grove roads. |
| Volcano | 2.88 | 14.62 | | 2,075 | |
| ** The following are the distances on the West Point Fork:* | | | | | |
| Forks of the road | | | 6.39 | | Leave Antelope and Pine Grove road. |
| Divide between North Fork Mokelumne and South Fork Sutter Creek. | 0.39 | 0.39 | 6.00 | | Road forks west. |
| Crossing North Fork Mokelumne | 2.20 | 2.59 | 3.80 | 2,091 | Suspension bridge. |
| West Point Post Office | 3.80 | 6.39 | | 2,749 | Mining village. |

† Not the same station given on the Amador road.

*From Hite's Cove to Mariposa Road, Cal.—Atlas-sheet No. 56 D.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Hite's Cove. | From Mariposa road. | | |
| Hite's Cove | ........ | ........ | 16.29 | .......... | |
| Bobbio's Ranch, or Snyder Gulch | 5.88 | 5.88 | 10.41 | .......... | |
| Saw-mill on Footman's Gulch | 1.07 | 6.95 | 9.34 | .......... | |
| Snow Creek | 4.44 | 11.39 | 4.90 | .......... | |
| Mariposa road | 4.90 | 16.29 | ........ | ......... | 260 yards east of Boot-jack Ranch. |

LISTS OF DISTANCES BETWEEN IMPORTANT POINTS MEANDERED BY PARTY NO. 1, COLORADO SECTION, DURING 1878.

Fest's Ferry, N. Mex., to Saint John's, Ariz.
Springerville, Ariz., to Milligan's road, Ariz.
Springerville, Ariz., to Luera Spring, N. Mex.
Ojo Caliente, N. Mex., to Fort Tulerosa, N. Mex.
Fort Bayard, N. Mex., to Mexican Boundary, via Eureka.
Fort Bayard, N. Mex., to Mexican Boundary, via La Tenaja.
Fort Bayard, N. Mex., to Las Cruces, N. Mex.
Fort Bayard, N. Mex., to Palomas, N. Mex.
Silver City, N. Mex., to Fort Tulerosa, N. Mex.
Saint John's, Ariz., to Springerville, Ariz.
Alamillo, N. Mex., to Fort Bayard, N. Mex.

*From Fest's Ferry, N. Mex., to Saint John's, Ariz.—Atlas-sheets Nos. 84, 77, and 76.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Fest's Ferry. | From Saint John's. | | |
| Fest's Ferry | ........ | ........ | 179.47 | 4,184 | Ferry and ford on Rio Grande. |
| Alamosa | 22.50 | 22.50 | 156.97 | 5,177 | Mexican town; water and grass; wood scarce. |
| Ojo Caliente | 17.20 | 39.70 | 139.77 | 6,061 | Hot springs; water, wood, and grass; Indian reservation.<br>Wood and grass; no water. |
| Forks (to Patterson) | 8.70 | 48.40 | 131.07 | 6,464 | Do. |
| Divide | 7.00 | 55.40 | 124.07 | 7,199 | Crossing of dry plain. |
| North Star road | 5.50 | 60.90 | 118.57 | 7,174 | Water, wood, and grass. |
| Luera Spring | 7.80 | 68.70 | 110.77 | 7,585 | Good water, wood, and grass. |
| Ensinoso | 16.50 | 85.20 | 94.27 | 7,204 | Fine timber and grass; no water. |
| Continental Divide | 14.00 | 99.20 | 80.27 | 7,977 | |
| Rito Mangos | 6.20 | 105.40 | 74.07 | 7,319 | Mexican settlement; water, wood, and grass. |
| Rita Quemada | 13.68 | 119.08 | 60.39 | 6,827 | Do. |
| Forks (to Springville) | 21.00 | 140.08 | 39.39 | .......... | Wood and grass. |
| Salt Lake | 0.50 | 140.58 | 38.89 | 6,344 | Sweetwater spring at lake; wood, and grass. |
| Pond | 5.00 | 145.58 | 33.89 | 6,472 | Water most of the year; wood and grass. |
| Tule Spring | 16.00 | 161.58 | 17.89 | 5,861 | Water and grass; wood near by. |
| La Pilla | 4.95 | 166.53 | 12.94 | 5,850 | Do. |
| Saint John's | 12.94 | 179.47 | ........ | 5,650 | Mexican town; water and grass; no wood. |

The grade on this route is excellent, and road-bed generally very good, with little sand. Somewhat marshy at intervals between Rita Quemada (where the Albuquerque freight road joins) and Tule Spring in the wet season.

*From Springerville, Ariz., to Milligan's Road, via Los Lentes.—Atlas-sheets Nos.* 76 *and* 83.

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Springerville. | From Milligan's Road. | | |
| Springerville | ...... | ........ | 60.64 | 6,862 | Becker's store. |
| Cienega | 10.25 | 10.25 | 50.39 | 7,476 | Ranches, water, wood, and grass. |
| William's Ranch | 6.25 | 16.50 | 44.14 | 7,487 | Upper ranch, on Nutrioso Creek. |
| Divide | 6.29 | 22.79 | 37.85 | 8,262 | Fine timber and grazing; water near on either side. |
| Bush's Ranch | 2.87 | 25.66 | 34.98 | 7,704 | Upper ranch on San Francisco River. |
| Settlement | 2.75 | 28.41 | 32.23 | 7,663 | Road leaves valley. |
| Stream | 4.07 | 32.48 | 28.16 | 7,671 | Impassable for wagons: hills descending to stream; water, wood, and grass. |
| San Francisco River | 3.61 | 36.09 | 24.55 | 7,235 | Water, wood, and grass; road in poor condition. |
| Mexican Ranch | 6.18 | 42.27 | 18.37 | 6,733 | Do. |
| Los Lentes | 3.25 | 45.52 | 15.12 | 6,542 | Mexican settlement; water, wood, and grass. |
| Paria's Spring | 5.70 | 51.22 | 9.42 | 6,896 | Water, wood, and grass. |
| Milligan's Road | 9.42 | 60.64 | ........ | 7,156 | Carrizo Spring 0.5 mile to the east. |

This road is good to settlement, but little used, and the present route is impracticable between settlement and where it rejoins river. Good from Los Lentes to Milligan's Road.

*From Springerville, Ariz., to Luera Spring, N. Mex., via Milligan's Road.—Atlas-sheets Nos.* 76, 83, *and* 84.

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Springerville. | From Luera Spr'gs. | | |
| Springerville | ...... | ........ | 110.25 | 6,862 | |
| Coyote Spring | 9.10 | 9.10 | 101.15 | 6,874 | Water, wood, and grass; road forks to Salt Lake. |
| Cienega Amarilla | 11.31 | 20.41 | 89.84 | 7,179 | Water, wood, and grass. |
| Oak Spring | 12.47 | 32.88 | 77.37 | 7,741 | Do. |
| Rancheria Vieja | 4.50 | 37.38 | 72.87 | 7,300 | Water scant; 0.5 mile up cañon wood and grass. |
| Road Junction | 10.40 | 47.78 | 62.47 | 7,220 | Carrizo Spring 0.5 mile up east drain, at junction of dry drain of Apache Creek. |
| Apache | 5.10 | 52.88 | 57.37 | 7,324 | Water, wood, and grass; Mexican settlement. |
| Gallo Spring | 4.90 | 57.78 | 52.47 | 7,587 | Do. |
| Forks to Tulerosa | 8.90 | 66.68 | 43.57 | 7,174 | Through northern cañon. |
| Divide and forks | 3.81 | 70.49 | 39.76 | 7,155 | Upper road to Tulerosa. |
| Forks (to Patterson's) | 5.46 | 75.95 | 34.30 | 6,912 | Dry plain. |
| Horse Spring | 9.30 | 85.25 | 25.00 | 7,045 | Ranch; water and grass. |
| Rito Mangos road | 23.00 | 108.25 | 2.00 | .... .... | Wood and grass. |
| Luera Spring | 2.00 | 110.25 | ........ | 7,585 | Water, wood, and grass. |

Road in good condition for wagon train, with the exception of a short piece between Apache and the Gallo; this, however, may be avoided by taking the road to the left at "Road Junction" and passing by way of Carrizo Spring, join the main road 1 mile before reaching the Gallo. This route will be found to be a shorter distance by about 2 miles than the one given.

*From Ojo Caliente to Fort Tulerosa (abandoned), N. Mex.—Atlas-sheets Nos.* 84 *and* 83.

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Ojo Caliente. | From Fort Tulerosa. | | |
| Ojo Caliente | | | 64.96 | 6,081 | Indian agency. |
| Forks | 8.70 | 8.70 | 56.26 | 6,464 | Wood and grass; no water. |
| Winter Spring | 4.30 | 13.00 | 51.96 | 7,182 | Water scarce; wood and grass plenty. |
| North Star road | 4.00 | 17.00 | 47.96 | 7,325 | Wood and grass. |
| Water-hole | 2.00 | 19.00 | 45.96 | 7,416 | Fine grazing; wood; water not permanent. |
| Forks | 0.50 | 19.50 | 45.46 | 7,464 | Leaves North Star road. |
| Water-hole | 6.80 | 26.30 | 38.66 | 7,335 | Grass; little wood; water in wet season. |
| San Augustin Plain | 6.50 | 32.80 | 32.16 | 6,780 | Fine grazing, east side. |
| Patterson's Ranch | 19.50 | 52.30 | 12.66 | 6,720 | Water and grass. |
| Continental Divide | 4.16 | 56.46 | 8.50 | 6,912 | Forks, upper road; water, wood, and grass. |
| Fort Tulerosa | 8.50 | 64.96 | | 6,612 | Old post; Mexican settlement. |

Good road with the exception of a steep hill between Forks and Water-hole. Intersection of Horse Spring road, 10 miles from Patterson's.

*From Fort Bayard, N. Mex., to Mexican Boundary, via Eureka.—Atlas-sheets Nos.* 84 *and* 90.

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Fort Bayard. | From Mexican Boundary. | | |
| Fort Bayard | | | 92.18 | 6,068 | |
| Apache Tejo | 11.20 | 11.20 | 80.98 | 5,478 | Warm spring; good water and grass; no wood. |
| Davis Ranch | 0.80 | 12.00 | 80.18 | 5,405 | Water and grass; no wood. |
| Cow Spring | 15.75 | 27.75 | 64.43 | 5,001 | Water and grass. |
| Forks | 0.40 | 28.15 | 64.03 | 4,975 | To Carrizillo Spring. |
| Eureka | 38.30 | 66.45 | 25.73 | 4,746 | Well; water scarce; grass; no wood. |
| La Lacha | 3.53 | 69.98 | 22.20 | 4,756 | Spring; good water; grass; little wood. |
| Mexican Boundary | 22.20 | 92.18 | | | Dry plain; grass; no wood. |

Between Davis Ranch and Cow Spring, road crosses a number of dry ravines and is somewhat broken. The bed is good except a short miry piece in drain from Silver City. Good grass is found between Cow Spring and Eureka, but no wood except occasionally mesquite, soap weed, or cactus. From the Mexican Boundary to Mesquite Spring the distance is 3.8 miles.

*From Fort Bayard, N. Mex., to Mexican Boundary.—Atlas-sheets Nos. 84 and 90.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Fort Bayard. | From Mexican Boundary. | | |
| **Fort Bayard** | | | 75.80 | 6,068 | |
| Cow Spring | 27.75 | 27.75 | 48.05 | 5,001 | Water and grass; no wood. |
| La Tenaja | 32.30 | 60.05 | 15.75 | 4,701 | Water scarce; wood and grass. |
| Carrizillo Spring | 10.00 | 70.05 | 5.75 | 4,457 | Water and grass; no wood. |
| **Mexican Boundary** | 5.75 | 75.80 | | | Dry, grassy plain. |

An old and much traveled road to Chihuahua. Bed very good. From Mexican Boundary to Mesquite Spring, eighteen miles; water holes five miles across the boundary.

*From Fort Bayard to Las Cruces, N. Mex.—Atlas-sheet No. 84.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Fort Bayard. | From Las Cruces. | | |
| **Fort Bayard** | | | 101.20 | 6,068 | |
| Apache Tejo | 11.20 | 11.20 | 90.00 | 5,478 | Warm spring; good water and grass. |
| Hot Springs | 9.50 | 20.70 | 80.50 | 5,008 | Government agency; good water and grass. |
| Miembres | 5.00 | 25.70 | 75.50 | 4,920 | Town and crossing; good water and grass. |
| Old Fort Cummings | 19.50 | 45.20 | 56.00 | 4,840 | Government agency; good water and grass. |
| Slocum | 31.10 | 76.30 | 24.90 | 4,519 | Do. |
| Forks* | 5.00 | 81.30 | 19.90 | 4,596 | Near Fort Selden; dry country; no wood. |
| Picacho Crossing | 15.70 | 97.00 | 4.20 | 3,784 | Ford of Rio Grande; dangerous; quicksand bottom. |
| **Las Cruces** | 4.20 | 101.20 | | 3,797 | Town and post-office; government agency. |

This is the stage-route from the Rio Grande to Fort Bayard

* Freight trains that go over the Jornada del Muerto can cross at Fort Seldon by the ferry and join stage-road at the Forks 11.07 miles distant.

### *From Fort Bayard to Palomas, N. Mex.—Atlas-sheet No.* 84.

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Fort Bayard. | From Polomas. | | |
| Fort Bayard | ........ | ........ | 82. 40 | 6, 068 | Government post. |
| Santa Rita | 6. 00 | 6. 00 | 76. 40 | 6, 161 | Settlement; copper mines. |
| Magruder's | 9. 60 | 15. 60 | 66. 80 | 5, 811 | Reduction works. |
| Crossing of Rio Mimbres | 10. 50 | 26. 10 | 56. 30 | 5, 355 | Bad in wet season. |
| Forks of trail | 1. 27 | 27. 37 | 55. 03 | 5, 442 | On bluff. |
| Nine-mile Cañon | 3. 80 | 31. 17 | 51. 23 | 5, 413 | Water in wet season; wood and grass. |
| Spring | 8. 90 | 40. 07 | 42. 33 | 6, 223 | Water, wood, and grass. |
| Berenda Creek | 3. 65 | 43. 72 | 38. 68 | 5, 489 | Do. |
| Road | 5. 80 | 49. 52 | 32. 88 | 5, 047 | Grass; little water and wood. |
| Oak Spring | 4. 80 | 54. 32 | 28. 08 | 5, 243 | Good water; wood and grass. |
| Apache Cienega | 1. 68 | 56. 00 | 26. 40 | 5, 291 | Water and grass; no wood. |
| Hillsboro | 4. 24 | 60. 24 | 22. 16 | 5, 224 | Mining town; gold. |
| Animas River (trail) | 10. 66 | 70. 90 | 11. 50 | 4, 470 | Water, wood, and grass. |
| Palomas | 11. 50 | 82. 40 | ........ | 4, 127 | Mexican town on Rio Grande. |

Good road and easy grades to forks of trail and road beyond the crossing of the Miembres. The route is then by trail to where it meets the Hillsboro road, 1.75 miles to north of McEver's Ranch. From Hillsboro to Palomas the route is by trail across the plains.

### *From Silver City to Fort Tulerosa (abandoned), N. Mex.—Atlas-sheets Nos.* 84 *and* 83.

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Silver City. | From Fort Tulerosa. | | |
| Silver City | ........ | ........ | 120. 95 | 5, 771 | Mining town and post-office; population, 1,400. |
| Old saw-mill | 8. 25 | 8. 25 | 112. 70 | 6, 042 | Wood, water, and grass; road. |
| Walnut Creek | 4. 25 | 12. 50 | 108. 45 | 5, 550 | Wood, water, and grass; trail. |
| Bear Creek | 8. 15 | 20. 65 | 100. 30 | 4, 737 | Dry bed; rough country; wood plenty; trail. |
| Upper Gila | 8. 75 | 29. 40 | 91. 55 | 4, 428 | Settlement; wood, water, and grass; trail. |
| Patterson's Ranch | 5. 10 | 34. 50 | 86. 45 | 4, 590 | Wagon road; fine grazing; cottonwoods. |
| Springs | 2. 30 | 36. 80 | 84. 15 | 4, 697 | Head Creek; cottonwoods; fine grazing. |
| Spring | 13. 75 | 50. 55 | 70. 40 | 4, 968 | Good water 200 yards down gulch; little wood; fine grazing. |
| Whitewater Creek | 12. 15 | 62. 70 | 58. 25 | 4, 678 | Settlement; water, wood, and grass. |
| Ranch | 6. 50 | 69. 20 | 51. 75 | 4, 863 | Meadows; water and grass. |
| San Francisco River | 3. 00 | 72. 20 | 48. 75 | 4, 944 | Crossing. |
| Do | 8. 00 | 80. 20 | 40. 75 | 5, 168 | Return to river. |
| San Francisco (lower) plaza | 15. 41 | 95. 61 | 25. 34 | 5, 639 | Mexican town; wood, water, and grass. |
| San Francisco (middle) plaza | 2. 45 | 98. 06 | 22. 89 | 5, 638 | Do. |
| San Francisco (upper) plaza | 2. 14 | 100. 20 | 20. 75 | 5, 688 | Do. |
| Fort Tulerosa (abandoned) | 20. 75 | 120. 95 | ........ | 6, 612 | Do. |

This route intersects the main wagon route to Tulerosa at Patterson's Ranch, which, from Silver City, passes by Mangos Spring and old Fort West, and is about four miles longer than the route given. From Whitewater the road has been little used, and that portion which is in the cañon of the San Francisco, between San Francisco River and lower plaza, is almost impassable for wagons.

*From Saint John's, to Springerville, Ariz.—Atlas-sheet No. 76.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Saint John's. | From Springerville. | | |
| St. John's | ........ | ........ | 31.80 | 5,650 | Mexican town on Little Colorado; water and grass; no wood. |
| Chriswell's Ranch | 6.50 | 6.50 | 25.30 | 5,772 | Three springs; alkali water. |
| Tule Springs | 5.00 | 11.50 | 20.30 | 5,807 | Water, wood, and grass; Mexican ranch. |
| Ford | 4.00 | 15.50 | 16.30 | 5,875 | Do. |
| Vigil's Ranch | 2.50 | 18.00 | 13.80 | 6,034 | Do. |
| Ford | 1.65 | 19.65 | 12.15 | 5,967 | Do. |
| Springerville | 12.15 | 31.80 | ........ | 6,862 | Becker's store and post-office. |

Road hilly in parts, but generally good, and follows up the Little Colorado River.

*From Alamillo to Fort Bayard, N. Mex., via Georgetown.—Atlas-sheets Nos. 77 and 84.*

| | Distance in miles. | | | Altitude in feet above sea-level. | Remarks. |
|---|---|---|---|---|---|
| | Between consecutive points. | From Alamillo. | From Fort Bayard. | | |
| Alamillo | ........ | ........ | 181.87 | 4,600 | On Rio Grande; water, wood, and grass. |
| San Lorenzo Spring | 7.37 | 7.37 | 174.50 | 5,326 | Water, wood, and grazing. |
| Pueblo Spring | 17.61 | 24.98 | 156.89 | 6,398 | Water and grazing; little wood. |
| Monica Spring | 19.48 | 44.46 | 137.41 | 7,602 | Good water; wood and grass abundant. |
| Running stream | 2.50 | 46.96 | 134.91 | 7,740 | Water in wet season; wood and grass plenty. |
| Point of Rocks | 11.83 | 58.79 | 123.08 | 7,178 | Water in wet season; fine grazing and wood. |
| Forks (Ojo Caliente) | 6.33 | 65.12 | 116.75 | 7,174 | Dry prairie. |
| Water hole | 10.21 | 75.33 | 106.54 | 7,416 | Water in wet season; wood and grass plenty. |
| Forks (Patterson's Ranch) | 0.50 | 75.83 | 106.04 | 7,464 | Road from Ojo Caliente to San Augustin plain and Patterson's Ranch. |
| Spring | 11.25 | 87.08 | 94.79 | 7,291 | 0.5 mile east of road; fine grazing. |
| Shaw's Ranch | 2.10 | 89.18 | 92.69 | 7,256 | Fine water and grazing; wood abundant. |
| Springs | 13.40 | 102.58 | 79.29 | 6,927 | Old Camp Sherman; water, wood, and grass. |
| Mal Pais Creek | 8.20 | 110.78 | 71.09 | 6,593 | Water, wood, and grass. |
| Gila River | 6.34 | 117.12 | 64.75 | 6,188 | Old Camp Vincent; junction Warm Spring Creek. |
| Agate Creek | 4.18 | 121.30 | 60.57 | 6,329 | Bad crossing in wet season. |
| Black River | 14.90 | 136.20 | 45.67 | 6,702 | Water, wood, and grass. |
| Rocky Cañon | 6.65 | 142.85 | 39.02 | 7,595 | Do. |
| Willow Creek | 5.58 | 148.43 | 33.44 | 7,344 | Do. |
| McKnight's Ranch | 9.74 | 158.17 | 23.70 | 6,237 | Water, wood, and grass; 0.5 mile from Mimbres River. |
| Forks (to Magruder's) | 8.15 | 166.32 | 15.55 | 5,864 | Wood, water, and grass. |
| Georgetown | 3.50 | 169.82 | 12.05 | 6,455 | Mining town; wood and water. |
| Santa Rita | 6.10 | 175.92 | 5.95 | 6,161 | Copper mines; wood, water and grass. |
| Forks (to Santa Clara) | 3.10 | 179.02 | 2.85 | 5,857 | |
| San José | 1.35 | 180.37 | 1.50 | 6,028 | Gold mines; arrastra. |
| Fort Bayard | 1.50 | 181.87 | ........ | 6,068 | Government post; post-office |

The greater part of this route is along the North Star road, which leaves the Rio Grande near the mouth of the Puerco River, and passing by Ojo de la Quinca joins this route near the north point of Madelena Mountains, where ther oad from Socorro also joins. At Point of Rocks the road forks to Luera Spring, distant 16 miles. From forks (Ojo Caliente) to Ojo Caliente the distance is 21.20 miles. Ojo Caliente to Shaw's Ranch, partly by road and partly by trail, the distance is 18.8 miles. Below old Camp Sherman the road is in a closed marshy cañon for about two miles; road follows down Gila River one mile, up bed of Black River one mile, after crossing. The distance can be shortened several miles by taking trail to left at Agate Creek and join road again on high ridge to south; distance by trail 4.66 miles. Down Rocky Cañon for four miles the road is very bad and almost impassable for wagons. Farming settlements along Mimbres River between McKnight's and Magruder's.

## MINING NOTES.

The overground survey of the Washoe mining region was carried to completion, the data for the contouring of the southeast corner having been secured early in the season. The remaining examinations were confined to air velocities, volumes and temperatures in some of the more important shafts, various levels, and in the Sutro Tunnel. Collections from the ore channels and country rock were made from shafts, drifts, and tunnels, as circumstances permitted.

Rock temperatures now being made at a few of the main shafts show present, and promise future interesting results. The contour map, drawn to a scale of 1 inch to 500 feet, is completed. The map will serve as a basis for engineering calculations, and also for delineation of the results from such further study of the ore-bearing channels and rocks of this region as may be made from time to time.

The outline map, herewith, shows the location and surface extent of all the mines for which patents have been issued, as given by a list received from the Land Office, up to the date stated on its face, together with a number of others now on the records of the General Land Office, and for which application for patent has been made. This map will be printed also in curves, giving differences of elevation of 50 feet. The relative and positive elevations of all working shafts are noted, the position of mills, mining settlements, and their approaches, together with croppings, &c. This map illustrates, in a measure, the application of the surface claim of the last mining law, and shows clearly cases where litigation may readily arise, especially on account of varying angles of the side lines of adjoining claims, and because vertical planes passed through the end lines of adjoining claims may, in instances, either intersect or enter the adjoining claim at given depths along the dip of the lode. This is the more marked in the locations made along the eastern line of crop, which is usually but poorly defined.

This map further illustrates the comparatively small amount of ground that the government parts title with in granting patents for mining claims. A transcript has been kept of the progress of the underground work of the district, and traced copies of the maps secured to keep up the set, showing the extent of the mine explorations, and also the progress of the Sutro Tunnel, that has now tapped the vein proper and is employed as a means of drainage.

The material at hand is sufficient upon which to base cross-sections at the most prominent points along the vein, the horizontal sections of all the working levels, and a vertical section along the whole lode.

I desire again to advert to the courtesy shown by Messrs. James and Wrinkle and Messrs. Craven, Hoffman, and Gignoux, all mineral surveyors of Virginia City, while myself and parties have been engaged in gathering data for the surface maps and the below-surface workings of the Comstock mines.

The contour map, together with the above sections, afford sufficient material upon which to base a relief model, showing the shape of the surface and the relative positions thereto of the underground workings.

A condensation of notes made at a number of mining districts in the usual form is herewith:

### RIDGE BAR MINING CAMP, KERN COUNTY, CALIFORNIA.

[From notes by Lieut. Willard Young.]

This camp had not been regularly organized into a district in September, 1878, the time of our visit. It is situated in the Kern River Cañon, about five miles above the mouth.

The claim covers about 160 acres, and consists principally of a large gravel deposit, forming a ridge nearly parallel to the river and directly in the bed of the old stream. The camp gets its name from this fact. It was first discovered in April, 1878, and has been worked continuously since. The post-office is Bakersfield, distant about 25 miles. The country rock in the vicinity and above is granite. There are two claims now being worked, the Enterprise and the Chinaman. A ditch and flume, about 3½ miles in length, are being constructed, to carry the water of

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Lucas Creek to these claims, which, when completed, will furnish about 2,000 miner's inches of water. Two thousand five hundred dollars have already been expended on this work, and it is estimated that it will take $1,500 more to finish it. Labor costs about $2 for white men and $1.25 for Chinamen, per day. Hay costs 1 cent and barley 2½ cents per pound. They are brought from Bakersfield. There is plenty of wood and grass in the vicinity. About 25 men are now at work. Country roads are very bad. Deer, bear, quail, and grouse are found in the neighborhood. The gravel is said to be quite rich, and it is estimated that, by ground-sluicing, one man can wash out $10 per day.

### SAN GABRIEL DISTRICT, LOS ANGELES COUNTY, CALIFORNIA.

[From notes by Lieut. Willard Young.]

This district comprises the whole mountain region drained by the San Gabriel River. It was first discovered in 1852, by Captain Hanegar and Mr. Thos. Driver. Little or nothing was done until 1858; but since this time the district has been worked continuously. The post-office is Azusa, a small town near the mouth of the cañon. From the main mining camp, twelve miles up the cañon, to the railroad at San Gabriel Mission is about 33 miles. No geological investigation has been made, except along the cañon for about 3 miles above its mouth to the Winston Silver Mine, which was visited by Professor Marcou in 1875.

The principal work now being done is on the placer mines along the river, there being some hundred or more claims located; and on two hydraulic claims, comprising large tracts of gravel banks, with ditches and flumes to convey the necessary water. These latter have been in operation since 1874, the gravel deposits being some 80 feet in depth, and from 100 to 200 feet above the present river bed. These deposits are almost inexhaustible, and will afford employment to the present owners and workers for years to come. There are several veins in the vicinity of the Winston Mine now being worked, all yielding silver ore; but nothing definite could be ascertained as to their extent or richness. The characteristics of the ores are the same as those at the Winston, which, in their composition and in the manner in which they are found, are said to resemble very closely the rich silver ores of Virginia City, Nev. All assays thus far have shown the presence of gold. The amount of money expended in constructing ditches and in machinery and labor for the hydraulic claims is about $32,000. Amount of gold extracted per annum from these claims about $12,500. Expended on Winston Mine, $8,000, principally in running tunnels and shafts. Little or no returns have yet been realized.

The placer mines have been worked principally by Mexicans, and it is impossible, on that account, to obtain any statistical information. It is believed, however, that the total amount of gold produced from these mines since 1858 will exceed $2,000,000.

Timber, in considerable quantities, abounds in the entire district, with large pineries on the northern and eastern boundaries. The district is well watered by the San Gabriel River and its tributaries, which afford water in sufficient quantity for hydraulic mining and milling purposes. The road up the cañon is very rough. Deer, bear, quail, wild pigeons, and gray squirrels abound. There are now about 150 inhabitants in the district. Hay, grain, and farm produce are easily obtained from the San Gabriel Valley. Labor costs $2 per day.

### SAN ANTONIO DISTRICT, SAN BERNARDINO COUNTY, CALIFORNIA.

[From notes by Lieut. Willard Young.]

This district comprises the country drained by San Antonio Creek. It was first organized in 1872, and was reorganized in October, 1878. But very little work has been done in this district since its first discovery. The post-office is Cucamonga; and Cucamonga Station, distant 11 miles, is the nearest railroad point. No geological investigation has been made. Mineral croppings are found in the cañon on either side of the creek; and one ledge is situated near the summit of San Antonio Peak. None of them have yet been developed to any extent. The principal mines are the Shell Bark, Gilbert, and Elmore, all placers; and the Clark, near the summit of San Antonio, and the Red, White, and Blue, on the east side of the cañon, both quartz.

I was unable to find out the composition of the ores of the Clark and other vein mines. Rich placers, just discovered in the bed of the creek, gave new life to the work there, and, as a consequence, locations have been made along the creek for nearly its whole length. Nothing of any consequence had been done up to the time of our visit. Labor costs $2 per day. Hay 1 cent and barley 1½ cents. These and farm produce, &c., are easily obtained from Cucamonga and the valley below. Wood and water are abundant; grass only moderately so. Game is scarce, though deer, mountain sheep, pigeons, and quail are found.

The district will, I think, never be of any great importance.

### HOLCOMB VALLEY DISTRICT, SAN BERNARDINO COUNTY, CALIFORNIA.

[From notes by Lieut. Willard Young.]

This district was first discovered in 1860, by William Holcomb, and was organized in the spring of 1861. It has been worked continuously since that time. The post-office is San Bernardino, distant by trail 40 miles, and by wagon-road 75 miles. A good road runs from Cajon Pass to the district. It is situated in the mountains, north by northwest from San Bernardino Mountain, and is bordered on the north by the Mojave Desert; on the south by the Santa Ana River; on the east by Bear Valley; on the west by the desert hills, near the forks of the Mojave River. The district is about 10 miles square, and mineral croppings are found pretty nearly over the whole area. No special geological investigations are known to have been made.

The general trend of the mountains in the vicinity is from west to east, with spurs running from north to south. The mining ledges are situated, some near the top of the mountain, and others in cañons and on both the north and south slope of the mountains. The general direction of the lodes is a little north of west, except at the Green Lead Mine, where it runs from north to south. The wall rock is granite, with a dip of 40° to 45° towards the south. Near the Green Lead, which is towards the western boundary of the district, the country rock is limestone and granite. In Holcomb Valley proper the rock is entirely granitic. The gold ores at Holcomb Valley yield from $7 to $80 per ton and are worked by the free process. The silver ores are smelted. There are a great many placer claims here also. The ore from the Green Lead is roasted. At Holcomb Valley the water level has been reached at about 100 feet, more sulphurets being found below than above this level. At the Green Lead, water level was reached at about 300 feet, but no change in the ore was noted. At Holcomb Valley the gold-bearing quartz and the placers are found on the south side of the main mountain ridge. The silver and lead bearing veins are on the north slope of this ridge, towards the desert. The average yield from the latter is about $40. They have not been much developed. The ore from the Green Lead is worked for gold only, but it contains some silver and a great deal of copper.

There was no work being done in the district at the time of our visit, except by a few Spaniards at some of the placers. There are a sawmill and a stamp-mill here, both run by a 10-horse-power engine. The stamp-mill has five stamps of 750 pounds each. A 10-stamp mill, without furnace, would cost, with transportation and putting up, about $12,000.

Mining the ore costs about $7 per ton; milling the ore, $7 per ton; mining labor per day, $3; milling labor, $3,50. Ore that can be stoped by one man in one day, about one ton; amount that can be extracted by one man in one day, about one-half ton. Cost per foot for running a tunnel, $8; for sinking a shaft, $15. Hay costs 1½ cents; barley 4 cents. There are no facilities for raising farm produce; present source of supply, San Bernardino. There is plenty of timber everywhere. Water is found only in wells. Number of inhabitants in the district, 15. Freight costs 2 cents per pound. Game is scarce. Country roads good. Principal mining companies and property holders are, the Holcomb Valley Mining Company (limited), London, England; and the Green Lead Mining Company, Los Angeles, Cal.

### BEAR VALLEY DISTRICT, SAN BERNARDINO COUNTY, CALIFORNIA.

[From notes by Lieut. Willard Young.]

The Bear Valley district is situated immediately east of, and adjoining the Holcomb Valley district, of which it used to form a part. It was organized in 1873, and since that time, has been worked continuously. San Bernardino is the post-office and general depot of supply. It is distant 50 miles by trail and 80 miles by wagon-road. The mining ledges here, as at Holcomb, are situated in cañons, along the foot-hills, and near the tops of the mountains. The veins generally run with the country rock. Wall rock is granite and slate. There are good evidences of permanent veins. All the ore is gold quartz, worked by the wet process, and yields about $20 per ton. The principal mines are the Gold Mountain, which has a shaft of 50 feet, and three tunnels, one of 300 feet and two of 100 feet, each; the Memphis, worked only on the surface, the vein being about 600 feet wide; and the Last Chance, worked only on the surface, vein 60 feet wide.

A few years ago there were several hundred inhabitants here, and quite a flourishing town sprang up. It is now pretty nearly deserted. At present, there is one 5-stamp mill in working order, the stamps weighing 350 pounds each. It is of but little value, and cannot work up more than two tons of ore per day. Most of the ore in the district is worked in arrastras, run either by horse or water power. The ore can be mined for about $3 per ton. Milling costs $10 per ton. Labor, forage, produce, &c., the same as at Holcomb Valley. Number of inhabitants in district, about thirty. Freight costs 2 cents; country roads good. Deer, geese, and ducks are the principal game. There is a store in the town of Bear Valley, supplying dry goods, groceries, and provisions. About $215,000 have been expended by the Gold Mountain Mining Company, principally on the mill, now burned down, and in improving the country roads. They have realized about $30,000 in bullion. The Memphis Company have expended $3,000, and have taken out $2,000. The Last Chance have expended $2,000, and have realized $2,000.

### LONE VALLEY DISTRICT, SAN BERNARDINO COUNTY, CALIFORNIA.

[From notes by Lieut. Willard Young.]

This district is situated in the mountains and hills bordering the Mojave Desert, near the San Bernardino Mountain, and lies southeast of Bear Valley district, and immediately adjoining it. It was discovered in 1873 by J. W. Wilson and J. E. McFee, and organized the same year. It has been worked continuously since. It is distant from Whitewater Station, on the Southern Pacific Railroad, by trail 50 miles and by road 85 miles; and from San Bernardino, by road, about 90 miles. The district is approximately 8 miles long, from north to south, by 5 miles broad, and mineral croppings are found over nearly the whole area.

No geological investigation has been made. The general trend of the mountains in the vicinity is northwest and southeast; and the mining ledges are found on either slope. Their general direction is parallel to the mountains, and they run with the country rock, which dips to the southwest, from 30° to 40°. No large leads have yet been developed. Wall rock is granite. The country rock is limestone and granite. The principal ores are gold quartz and galena, associated with iron pyrites and other sulphurets. Considerable copper is found at croppings. No fossils have been found. Gold averages from $35 to $40 per ton; silver, from $35 to $60 per ton. The gold quartz is worked in arrastras, by the wet process. No silver ores are being worked. Gold is present in all the ores.

The principal mines are the Silver Star, Old Jeff, National, Oro Fino, White Stockade, Big Blue, Rough and Ready. None of them have been extensively worked. About $2,000 have been expended on the Big Blue. At some of the others shafts, of from 20 to 30 feet have been sunk. Two arrastras are now being worked. A small smelting furnace was established here but is now abandoned. The ore can be mined for about $4 per ton. Melting the ore by arrastras cost $10 per ton. Labor costs $3 per day. Cost per foot for running a tunnel, from $7 to $10; for sinking a shaft, $8. Hay costs 1 cent, barley 3 cents. There are no facilities for raising produce of any kind. Present source of supply, Whitewater. There is an abundance of fine timber and plenty of wood. Grass and water are very scarce. Inhabitants in district, 10. Price of freight, 2 cents per pound. Deer, antelope, mountain sheep, rabbits, and quail are found, but are not plentiful. Country roads good.

### LONE DISTRICT, SAN MIGUEL COUNTY, NEW MEXICO.

[From notes by Lieut. Rogers Birnie, jr.]

This district was discovered in 1870 and organized in 1871, and has since been worked continuously. It is 350 miles from the terminus of the Atchison, Topeka and Santa Fé Railroad, via Hot Spring, Cottonwood Ranch, Fest's, La Parida, Punta del Agua, and Anton Chico. The district is 5 miles square, and about 1,200 acres near the center contain the mineral croppings, with a trend northeast and southwest. The deposits occur in limestone rock found crossing cañons and along the east side of the Lone Mountain hills, which trend nearly north and south. The wall rock is nearly perpendicular, with continuous veins, which have been easily traced to a depth of 50 feet by shafts. Much of the ore, however, has been taken from apparently isolated pockets. The ore is worked by the raw amalgamation process. Assorted ore averages 75 to

80 ounces of silver per ton. The characteristics of the ore are native silver and chloride, heavy brittle sulphurets in quantity, and in places lead, copper, and iron. Gold occurs in some of the mines.

The principal mines now operated are Home Ticket; vein opened 12 to 14 feet in depth for 1,000 feet; two shafts, 20 and 48 feet, with some water in the latter, probably from a crevice. The vein is 18 inches wide, dark and light quartz, in hard red limestone. The hanging wall is free and well defined, and has a pitch of 80°. Pino Carte, recently opened on what seems to be a well-defined ledge in limestone. A small opening has yielded ore, producing 52 ounces per ton. Bismarck, recently opened; two tons of ore yielded 33 ounces each. Red Lead has five shafts, one of 50 feet with a 10-foot drift; not worked during the year. There are several smaller mines with streaks of good ore, but not sufficient to pay for working. On all the mines labor has chiefly been performed by the owners. About 250 tons of ore was worked at the mines during the year, averaging about 100 ounces per ton.

There is one mill with an engine of 25-horse power, 4 stamps of 500 pounds, 2 ordinary arrastras for grinding pulp, and 2 amalgamating pans, old Varney patterns; capacity, 3 tons in 24 hours.

Georgetown ore is worked at this mill, averaging 150 ounces per ton; and Lone Mountain ore, averaging 100 ounces per ton, the charges being $20 to $25 per ton. The superintendent of the mill claims that grinding by arrastras saves 15 per cent. over iron pans. As most of the work is done by the mine owners, no prices of labor are determined. But little land in the district is tillable. Hay is $20 per ton, and grain 2½ cents per pound. There are a few small springs and a small stream in the district. Wood has to be brought 9 miles. Freight costs 4 cents from the railroad and 3 cents back. The roads are excellent. The district contains 38 inhabitants and about 500 head of stock. There is good grazing.

### CHLORIDE DISTRICT, SILVER CITY, NEW MEXICO.

[From notes by Lieut. Rogers Birnie, jr.]

This district was discovered and organized June 3, 1870, by John and James Bullard, E. Necks, and John Swisshelm. It has been worked continuously, although with decreased activity, since 1875. It is situated about 500 miles from Trinidad, the terminus of the railroad. The district was examined geologically by Dr. O. Lew, of this expedition, in 1873.

The country rock is very much broken. Slate and limestone predominate, with an occasional dike of igneous rock. The slate is usually barren, the ore occurring in streaks in limestone, being richest near line of contact with the slate. It is doubtful if true veins exist, those being found chiefly in pockets. No fossils. The smelting process failed because of the predominance of chloride, as also did roasting. The amalgamation wet process is now employed. The ore contains much base metal, and the workings have saved only about 60 per cent. of value. The ore has not been weighed, but during the past year the Bremen mill has run about 485 tons from the "'76" mines, the average working being 45 ounces to the ton. The ores are chiefly chlorides, together with black sulphurets and some native silver. There is probably a small amount of bromine copper; also lead, antimony, and iron. The vein matter is feldspar mixed with ores. The ores contain no gold. The principal mines are the '76, Two Ikes, New Issue, Republican, and R. E. Lee.

The '76 mine has several shafts sunk through a bed of slate, under which the ore occurs in beds and pockets.

The Providence is of the same class. The Two Ikes has been but little worked since 1875; one shaft is sunk 135 feet with driftings. An attempt to work this mine was made within a year, but failed to pay. $351,000 have been taken from this mine; expenses, $121,000. The New Issue has been idle for three years; but within six months a few tons of ore have been extracted, giving 109 ounces to the ton. The Republican has three shafts, 125, 35, and 48 feet; no drifts. Accurate information as to the amount expended in developments could not be obtained. The Bremen Mill has a 25-horse-power engine, 10 stamps, 10 Varney pans, 4 settlers. The Pope Mill has been idle for two years; it was run at a loss.

The average cost per ton for mining ore is $7; for roasting and milling, $12; for mining labor per day, Mexican, $2; American, $3. But little stoping is done. Amount of ore that can be extracted by one man per day, one-half ton; average cost per foot for running a tunnel, $7; for sinking a shaft, $9; for running a drift, $7. Hay is most abundant, and easily obtained from the adjacent plains; price per ton, $15; grain, 2½ to 3 cents per pound. There are 5,000 to 6,000 acres of cultivable land on Mimbres and Gila Rivers within one day's journey of town. Timber is at present obtained from Burro Mountains. Timber is worth $35 per thousand at mill; shingles, $5; laths, $9. At present rate of consumption, timber will last four years longer. Water is readily obtainable from wells 15 feet deep; the San Vincente spring in the town runs 35 inches.

### MIMBRES SILVER MINING DISTRICT, NEW MEXICO.

[From notes by Lieut. Rogers Birnie, jr.]

Discovered and organized by James D. Fresh April–June, 1873. It has been worked continuously. It is distant from Trinidad 525 miles. The district covers an area of 3 miles extending northeast and southwest. Geological investigations have been made by C. W. Irish, Iowa City, Iowa. The ledges are on the southeastern slopes of the Parapet Mountains. The deposits are in chimneys in limestone with frequent branches. The pockets occur very irregularly, the richest ores generally in vicinity of granite dikes. No real fissure veins can be traced. No fossils have been found in the ore-bearing limestone; in the limestone cappings of the hills many occur. The ores are worked by the free amalgamation process, one ton yielding 150 ounces. They occur as chlorides, sulphurets of silver, and as carbonates. Iron, antimony, and arsenic occur in small proportions. No gold is found. Water has not been reached. The principal mines are: 1. McGregor, with 12 shafts, averaging 50 feet each, and 2,500 feet of drifts; 2. Commercial, with 10 shafts of 50 feet each and 3,000 feet of drifts; 3. McNulty; 4. Naiad Queen, with 3 shafts aggregating 335 feet and connecting drifts; $600,000 have been expended in developments, all of which has been drawn from the mines. The camp has yielded $800,000.

There are two mills in the district. The Mimbres Mining and Reduction Works is situated on Mimbres River, 3 miles from Georgetown, and is run by water-power. It has 1 Blake crusher, capacity 25 tons per day; 5 stamps, capacity 4 tons per day; 3 settlers and 2 arastras. The capacity of this mill is soon to be materially increased.

Meredith's mill, on the Mimbres, is also run by water-power. It has no crusher; it has 3 stamps. Capacity of mill, 2½ tons per day. Cost of a 10-stamp mill, without roasting furnace, $15,000. Average cost of mining ore per ton, $40; for roasting and milling per ton, including transportation to mill, $30; average mining labor per day, $3; average amount of ore that can be extracted by one man per day, one-twelfth of a ton (200 pounds); average cost per foot for running a tunnel, $12 per foot; for sinking a shaft, $7.50 per foot; for running a drift, $12. Hay costs $20 per ton. There are about 5,000 acres of tillable land on Mimbres; stock facilities are excellent. A good supply of timber is found within 12 miles; wood abundant. Willow Spring in the town runs 4 or 5 inches of water, and, by digging, its capacity can probably be doubled.

There are 500 inhabitants in the district, the mines affording employment to 100 men. Four stages a week run to Silver City. Inward freight costs 4 cents per pound; outward, 3 cents. There are 3 stores, 1 school-house, 1 banking house; 100 head draught animals, 1,200 cattle, and 2,000 sheep and goats sum up the stock in the vicinity. Bear, deer, and quail are found. The country roads are good. There are no Indians in the district.

### PINOS ALTOS DISTRICT, GRANT COUNTY, NEW MEXICO.

[From notes by Lieut. Rogers Birnie, jr.]

This district was discovered and organized July, 1859, by Isa Langston, Captain Snively, and Mr. Birch. It has been worked continuously, but much less actively, since the winter of 1866. An area of about 3 miles square is covered by the outcroppings. Geological investigations have been made by Ross Brown; no special surveys obtainable.

The general direction of the lodes is north and south, and conforms to country rock. Uniformly low-grade ores are found in granite, the richest near junction of slate and granite; there are some rich deposits of gold in slate. Pyrites is met with in varying quantities; free gold is found with it. There are five old and well developed and apparently genuine fissure veins. The vein matter is usually inclosed by talc. The dip is nearly uniform (to west) from 75° to 82°. Granite, quartzite, and slate constitute the country rock. No fossils are found. The ores are worked by arastra process and only for free gold. A large quantity from Pacific mines Nos. 1 and 2 is said to have yielded an average of $40 to the ton. The Mina Grande about $8 per ton; but the latter ore is free from metals and pays best to work. Water is reached in Pacific mines about 300 feet from summit of hill; ore changes to pyrites. No water in Atlantic, which is sunk 125 feet.

Atlantic and Mina Grande ore contains a little iron and silver; Pacific contains iron pyrites in quantity, copper, carbonate and chloride of silver, iron, and probably some zinc. In the Langston silver predominates, and assays give $100 to the ton. All the above are worked only for gold. The principal mines are: 1. Atlantic with 1 tunnel 300 feet; 4 shafts 125 feet, 100 feet, 80 feet, 80 feet, and surface worked 15 to 20 feet for about a mile. 2. Mina Grande with 1 tunnel 45 feet long; 2 shafts aggregating 250 feet, and surface worked 10 or 12 feet for about 700 feet. 3. Pacific No. 1; 2 tunnels 700 feet and 75 feet; 12 shafts aggregating 800 feet; surface worked 12 to 15 feet for about 900 feet. 4. Pacific No. 2; tunnel now being run is 186 feet; 6 shafts aggregating 480 feet; surface worked 15 feet for 300 feet. 5. Langston; tunnel 500 feet long; 2 shafts 60 feet each. 6. Arizona; tunnel 200 feet long; 4 shafts aggregating 300 feet. 7. A number of narrow seams, many of which have proved rich. 8. A number of placer diggings on both north and south slopes of Pinos Altos Peak. As to amount expended in developments, no strictly reliable figures could be obtained; the following estimates were given:

| | Expended. | Extracted. |
|---|---|---|
| Pacific No. 1 | $250,000 | $125,000 |
| Pacific No. 2 | 75,000 | 25,000 |
| Arizona | 60,000 | 20,000 |
| Atlantic | 40,000 | 20,000 |
| Mina Grande | 4,000 | 10,000 |
| Unnamed veins | | 250,000 |

There are 3 mills with one 15 and two 25 horse-power engines, besides some 15 arrastras. A 10-stamp mill costs $15,000; an ordinary smelting furnace, $2,000; average cost per ton for mining ore, $5; for roasting and milling, $5; of mining labor per diem, $2; of milling labor per diem, $1.50; average amount of ore that can be stoped by one man in a day, one-half ton; average amount that can be extracted by one man in a day, one-half ton; average cost per foot for running a tunnel on main veins, $2; for sinking a shaft on main vein, $2; for running a drift on main vein, $2.50. Shafts and drifts should be run in vein matter.

There is plenty of hay in the vicinity, price $10 per ton; grain 2 cents per pound. The amount of agricultural land is small. Vegetables are raised without irrigation. Timber and wood are abundant and near at hand. There is sufficient water for milling and stock-raising purposes, but not for placer mining except during a few months of the year.

There are 300 inhabitants in the district, 1 school-house, and 3 stores. There is but a limited amount of stock. Deer, bear, turkeys, and quail are found. The roads are good. Freight costs $4 per hundred; back freight, $2.50. The Apaches were very troublesome from 1860 to 1865, and have killed probably 40 men. No depredations have been committed since 1874; none now living in the vicinity.

*Placer mining.*—There are a number of placer diggings on north and south slopes of Pinos Altos Creek. Work is mostly confined to the months of June, July, and August (the rainy season). About 15 men are now at work, using cradles in the dry season. The average per day per man is $2; $300,000 is the estimated profit from the placers.

### LAS ANIMAS DISTRICT, COLORADO.

[From notes by Louis Nell.]

This district was discovered and organized by David Shitsel, May 22, 1877. It is distant from Trinidad 428½ miles. No geological investigations have been made. The district is situated in the foot-hills of the Mimbres Mountains, and is about five miles square; general direction of the lode northeast and southwest. The country rock is granite; no fossils found. The ore contains free gold, is worked by the free process, and yields from $20 to $35 per ton; base metals, copper and iron. Water is reached in some of the mines at a depth of from 40 to 60 feet.

The principal mines are the Snake, Golden King and Extension, Weeks Extension, Bobtail, Red Jacket, Yellow Jacket, Argosy, Eldorado and three extensions. From the Snake about $4,500 (in ore on dump) has been extracted; the same from the Bobtail. Some $20,000 worth of ore has been taken from the district in seven months. A Hillsboro mill was *en route*, and expected to be in operation by January, 1879. Average cost per ton for mining ore, $5; for milling, $10; for mining labor per day, $2.50; average amount of ore that can be stoped by one man in one day, one ton; average amount that can be extracted by one man in one day, about one-half ton; average cost per foot for running a tunnel on main vein, $4; average cost per foot for sinking a shaft on main vein, $5; average cost per foot for running a drift on main vein, $1.25. Shafts and drifts should be run in vein matter.

There is abundance of grazing and plenty of water. Timber is abundant 10 miles from the town. There are about 300 inhabitants, including Mexicans. There are 20,000 head of stock in the vicinity, including sheep, cattle, and horses—principally sheep. The country roads are very poor. The route in use follows up the bed of Animas River, and is subject to "wash-outs." Freight costs 3 to 4 cents; stage fare from railroad, $80. Deer, antelope, bear, rabbits, turkeys, ducks, and geese are found.

### AZTEC AND MORENO DISTRICTS, COLFAX COUNTY, NEW MEXICO.

[From notes by Prof. J. J. Stevenson.]

The Aztec mining district, organized in 1869, was visited in 1876 by Mr. Conkling, of this expedition. But little change has taken place since his visit. A few new mines have been opened, but the productiveness of the district has not been increased materially.

The Moreno district, organized in 1869, embraces a part of the Moreno Valley between the mouth of the creek and Elizabethtown, and reaches to the crest of Old Baldy Mountain, so as to join the Aztec district. Placer mining alone is carried on in this district, but the lack of water prevents it from attaining much importance, although the gravels are very rich.

Both of these districts are easily reached by way of an excellent road leading up Cimarron Creek from Cimarron, and are on the direct road from that place to Taos. Wood and grass are abundant, and good crops of all the ordinary grains can be raised within the Aztec district. The Moreno district lies too high for successful farming, though very near the head of Cimarron Cañon wheat and barley have matured.

### LOS CERILLOS MINES, SANTA FE DISTRICT, NEW MEXICO.

[From notes by Prof. J. J. Stevenson.]

Los Cerillos are irregular hills, perhaps 20 miles west of south from Santa Fé. Many years ago the Spanish residents worked some silver mines there, but they could not have been very profitable, as the workings are not extensive. The region became the object of attention during 1879, and a large number of miners flocked to it. When visited in June of 1879 it had many prospecting shafts varying from 20 to 50 feet in depth; but the ore streaks were very thin and the prospects not altogether such as to satisfy any but a visionary miner. The ore is galena, carrying silver. Some of the assays show ore of fabulous richness.

The region is arid and no good water has been obtained in the hills. Timber is plenty but the grazing is poor.

### PLACER DISTRICTS, SANTA FE COUNTY, NEW MEXICO.

[From notes by Prof. J. J. Stevenson.]

The Placer districts of the Placer Mountains are about 25 and 35 miles, respectively, distant from Santa Fé in a west of south direction. Gold was discovered in the Old Placer during 1828, and the gravels have been worked ever since. The New Placer was discovered at a somewhat later time. Water is scarce at both placers, and but little work can be done.

Quartz mining is carried on in a small way at the Old Placer. The New Mexican Mining Company erected a 20-stamp mill, but it is not in operation. Several lodes have been opened here, but they are irregular in thickness as well as quality. The New Placer was not examined.

In the vicinity of the placers water and grass are by no means abundant, but timber present for all necessities.

## NATURAL HISTORY (INCLUDING GEOLOGY, ZOOLOGY, &C.).

Prof. John J. Stevenson submits a preliminary report (Appendix K) of his examinations made along the mountain ranges southward from the Spanish Peaks in Colorado, and between the Rio Grande and the plains as far as the latitude of Santa Fe, lying mostly in atlas-sheets 70 A and 70 C. He was assisted by Mr. I. C. Russell, and the labors of the season proved distinctly satisfactory, both as regards geological data and in the collections of rocks and fossils. Twenty-six distinct coal horizons or beds from Trinidad to the south were noted, their order of succession distinguished, and the complicated axes of several mountain ridges determined. Resuming his labors in May of this year, he reviewed certain points of the field, and carried his examinations to the southern end of the Santa Fe axis, near Galisteo Creek.

Mr. H. W. Henshaw presents an ornithological report (Appendix L) upon regions traversed in 1876, 1877, and 1878, in portions of California, Nevada, and Oregon, as far to the northward as the Columbia River.

The following collections in natural history were made during the season:

| | | |
|---|---|---|
| Mammals | specimens | 8 |
| Mammals (alcoholic) | do | 3 |
| Mammal crania | | 1 |
| Bird skins | | 243 |
| Bird crania and sterna | | 7 |
| Birds' eggs | | 12 |
| Fishes | specimens | 200 |
| | lots | 12 |
| Snakes | specimens | 25 |
| | lots | 16 |
| Lizards | specimens | 25 |
| | lots | 7 |
| Batrachians | specimens | 50 |
| | lots | 11 |
| Hemiptera | lot | 1 |
| Orthoptera | specimens | 200 |
| | lots | 6 |
| Shells | specimens | 25 |
| | lots | 3 |
| Crustaceans | specimens | 12 |
| | lot | 1 |
| Fossil leaves | specimens | 72 |

The list of specimens forwarded during the year to the Smithsonian Institution to be deposited in the National Museum is herewith:

| | |
|---|---|
| Bird skins | 361 |
| Birds' eggs | 738 |
| Birds' nests | 19 |
| Mammal skins | 16 |
| Snakes | 24 |
| Lizards | 10 |

| | | |
|---|---|---|
| Batrachians | | 12 |
| Fishes | specimens | 400 |
| | lots | 35 |
| Orthoptera (alcoholic) | specimens | 500 |
| | lots | 14 |
| Orthoptera (pinned) | specimens | 150 |
| | lots | 4 |
| Hemiptera | specimens | 1 |
| | lots | 3 |
| Shells | specimens | 50 |
| | lots | 11 |
| Crustaceans | specimens | 12 |
| | lots | 1 |
| Plants | specimens | 100 |
| | lots | 2 |
| Invertebrate fossils | specimens | 2,159 |
| Rocks, approximated | | 2,494 |
| Minerals, ores, &c., approximated | | 1,993 |

### SPECIMENS FORWARDED TO ARMY MEDICAL MUSEUM.

| | | |
|---|---|---|
| Human crania | | 1 |
| Bird sterna | | 5 |
| Bird crania | | 5 |
| Mammal crania | | 2 |
| Alcoholic mammals | lots | 5 |

## PUBLICATIONS.

The following maps have been finished during the year, and will appear with the extra copies asked for of this report, viz:

Progress map for 1879 and seven regular atlas-sheets in hachures, with land classification color added, Nos. 32 D, 47 B, 47 D, 61 D, 73 A, 78 A, and 84 B. Volume VI, Botany, has issued from the Government Printing Office, and Volume VII is passing through the various stages of proof, preparatory to stereotyping. Two thousand extra copies of the Annual Report of 1878 from this office (Appendix N N, Annual Report Chief of Engineers) have been published, accompanied by ten separately bound atlas-sheets.

The following lists show the condition of reports add maps to date:

### REPORTS (PUBLISHED).

*Quartos.*

Volume II. Astronomy and Barometric Hypsometry.
Volume III. Geology.
Volume IV. Paleontology.
Volume V. Zoölogy.
Volume VI. Botany.
Volume VII. Archæology (in hands of printer).

*Annuals.*

(Separate from Report of Chief of Engineers.)

1873, 1874, 1875, 1876, 1877, 1878.

*Miscellaneous.*

(Quarto, octavo, and pamphlet.)

Two preliminary reports, 1869 (one octavo and one quarto).
Preliminary report, 1871 (quarto).
Progress report, 1872 (quarto).

Camps and distances, 1871 (oblong folio).
Camps and distances, 1872 (quarto).
Astronomical report, 1874 (quarto).
Star catalogue (quarto).
List of latitudes and longitudes (extract from Volume II).
Vertebrate fossils of New Mexico (pamphlet).
Catalogue of vertebrates of New Mexico (pamphlet).
Invertebrate fossils (pamphlet).
Catalogue of plants (octavo).
Ornithological specimens (octavo).
Meteorological instructions (octavo).
Barometric hypsometry instructions (octavo).
Field lists of stars (pamphlet).
Logarithm, traverse, and altitude tables (pamphlet).

## IN COURSE OF PUBLICATION.

Volume I, Geographical report (quarto).
Geographical positions, distances, &c.

NOTE.—It is intended to submit during the coming year the final report of Prof John J. Stevenson upon the result of his geological investigations of 1878 and 1879, and also his examinations of the coal beds of Eastern Colorado and New Mexico. This report is accompanied by a number of cuts, profiles, and maps, and will require considerable time and expense for its complete production.

## MAPS (PUBLISHED).

### *Topographical.*

Three sheets of conventional signs for (1) plotting and for final maps in (2) hachures; and (3) crayon hill shading.

Sheet of that portion of the United States lying west of the 100th meridian, showing ninety-five numbered rectangular divisions, each to appear as separately numbered atlas-sheets, indicating the progress of the survey. (Published for the years 1872–'73–'74–'75–'76–'77–'78–'79.)

Drainage sheet, showing by colors the area of drainage to the Atlantic and Pacific Oceans and the interior basins of the territory of the United States west of the Mississippi. Scale, 1:6000000.

### *Geological.*

Index sheet, showing the general topographical features and the rectangular divisions from Nos. 1 to 95.

Special sheet, embracing portions of Western Utah and Eastern Nevada, representing the location of an ancient fresh-water lake, which included the region of Great Salt, Sevier, and Utah Lakes. Scale, 1 inch to 17 miles.

### *Special.*

Reconnaisance map of parts of Nevada and Arizona. Scale, 1 inch to 12 miles, or 1: 760320.

Map of the Grand Cañon of the Colorado, expedition of 1871. Scale, 1 inch to 6 miles, or 1: 380160. (To accompany Vol. I.)

Topographical map of the vicinity of the Comstock lode in the Washoe mining region, Nevada: area, 119 square miles; scale, 1 inch to 1,500 feet, or 1: 18,000.

*Topographical atlas-sheets (published).*

| Atlas-sheet number. | Locality. | Scale. | Area, square miles. | Boundaries. | | | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Latitude north. | | Longitude west from Greenwich. | | | |
| | | | | ° | ′ | ° | ′ | ″ | |
| 32*d* | Part of Southeastern Idaho | 1 inch to 4 miles | 4,022.58 | 42<br>43 | 20<br>10 | 111<br>112 | 00<br>22 | 00<br>30 | * With land classification added. |
| 41*b* | Southeast corner of Idaho and part of Northern Utah. | do | 4,075.29 | 41<br>42 | 30<br>20 | 111<br>112 | 00<br>22 | 00<br>30 | ‡Also as land-classification map. |
| 47*b* | Parts of Eastern California and Western Nevada. | do | 4,178.42 | 39<br>40 | 50<br>40 | 119<br>120 | 15<br>37 | 00<br>30 | In skeleton. |
| 47*d* | do | do | 4,228.56 | 39<br>39 | 00<br>50 | 119<br>120 | 15<br>37 | 00<br>30 | *‡Also in hachures with land classification added. |
| 49 | Parts of Eastern Nevada and Western Utah | 1 inch to 8 miles | 16,813.96 | 39<br>40 | 00<br>40 | 113<br>116 | 45<br>30 | 00<br>00 | Also in crayon (hachure edition out of print). |
| 50 | Parts of Central and Western Utah | do | 16,813.96 | 39<br>40 | 00<br>40 | 111<br>113 | 00<br>45 | 00<br>00 | Also in geological form and crayon (hachure edition out of print). |
| 53*c* | Part of Central Colorado | 1 inch to 4 miles. | 4,228.56 | 39<br>39 | 00<br>50 | 104<br>105 | 07<br>30 | 30<br>00 | †Land classification to be added. |
| 57 | Parts of Southwestern Nevada and Eastern California. | 1 inch to 8 miles. | 17,208.58 | 37<br>39 | 20<br>00 | 116<br>119 | 30<br>15 | 00<br>00 | (Out of print.) |
| 58 | Part of Eastern and Southern Nevada and Southwestern Utah. | do | 17,208.58 | 37<br>39 | 20<br>00 | 113<br>116 | 45<br>30 | 00<br>00 | Also in crayon and partly in geological form (hachure edition out of print). |
| 59 | Part of Southwestern Utah | do | 17,208.58 | 37<br>39 | 20<br>00 | 111<br>113 | 00<br>45 | 00<br>00 | Also in geological form and in crayon (hachure edition out of print). |
| 61*a* | Part of West Central Colorado | 1 inch to 4 miles. | 4,278.00 | 38<br>39 | 10<br>06 | 106<br>108 | 52<br>15 | 30<br>00 | With land classification added (out of print). |
| 61*b* | Part of Central Colorado | do | 4,278.00 | 38<br>39 | 10<br>00 | 105<br>106 | 30<br>52 | 00<br>30 | Also as land-classification map (out of print). Geological classification to be added. |
| 61*c* | Part of Southwestern Colorado | do | 4,326.00 | 37<br>38 | 20<br>10 | 106<br>108 | 52<br>15 | 30<br>00 | *‡In skeleton, afterward with land classification; geological classification to be added. |
| 61*c*, sub. | Parts of Southwestern Colorado (San Juan mining region.) | 1 inch to 2 miles. | 1,100.00 | 37<br>38 | 42<br>07 | 107<br>107 | 15<br>57 | 00<br>00 | §In contours, and also as land-classification map. |
| 61*d* | Part of Southern Colorado | 1 inch to 4 miles. | 4,326.29 | 37<br>38 | 20<br>10 | 105<br>106 | 30<br>52 | 00<br>30 | *†With land classification added. |
| 62*a* | Part of Central Colorado | do | 4,278.00 | 38<br>39 | 10<br>00 | 104<br>105 | 07<br>30 | 30<br>00 | ‡Also as land-classification map. |
| 62*c* | Part of Central Colorado | do | 4,326.29 | 37<br>38 | 20<br>10 | 104<br>105 | 07<br>30 | 30<br>00 | ‡Do. |

* To accompany extra copies of annual report, 1879. ‡Separate edition with annual report, 1878. †Issued with extra copies annual report, 1877. §Accompanying extra copies annual report, 1876.

### *Topographical atlas-sheet (published)*—Continued.

| Atlas-sheet number. | Locality. | Scale. | Area, square miles. | Boundaries. | | | | | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Latitude north. | | Longitude west from Greenwich. | | | |
| | | | | ° | ' | ° | ' | " | |
| 65 | Parts of Southwestern Nevada and Southeastern California. | 1 inch to 8 miles | 17, 587. 88 | 35<br>37 | 40<br>20 | 116<br>119 | 30<br>15 | 00<br>00 | (Out of print.) |
| 65*d* | Part of Southeastern California | 1 inch to 4 miles | 4, 420. 20 | 35<br>36 | 40<br>30 | 116<br>117 | 30<br>52 | 00<br>30 | †Also as land-classification map. |
| 66 | Parts of Southeastern California and Nevada, Southwestern Utah, and Northwestern Arizona. | 1 inch to 8 miles | 17, 587. 88 | 35<br>37 | 40<br>20 | 113<br>116 | 45<br>30 | 00<br>00 | Also in crayon and geological form in part (hachure edition out of print). |
| 67 | Parts of Northern and Northeastern Arizona and Southern Utah. | ...do | 17, 587. 88 | 35<br>37 | 40<br>20 | 111<br>113 | 00<br>45 | 00<br>00 | Also as geological form and in crayon (hachure edition out of print). |
| 69*b* | Parts of Northern New Mexico and Southern Colorado. | 1 inch to 4 miles | 4, 373. 74 | 36<br>37 | 30<br>20 | 105<br>106 | 30<br>52 | 00<br>30 | †Also as land-classification map. |
| 69*d* | Part of North Central New Mexico | ...do | 4, 420. 20 | 35<br>36 | 40<br>30 | 105<br>106 | 30<br>52 | 00<br>30 | †§ Do. |
| 70*a* | Parts of Southern Colorado and Northern New Mexico. | ...do | 4, 373. 74 | 36<br>37 | 30<br>20 | 104<br>105 | 07<br>30 | 30<br>00 | †Also as land-classification map: geological classification to be added. |
| 70*c* | Part of Northern New Mexico | ...do | 4, 420. 20 | 35<br>36 | 40<br>30 | 104<br>105 | 07<br>30 | 30<br>00 | † Do. |
| 73*a* | Part of Southern California | ...do | 4, 465. 85 | 34<br>35 | 50<br>40 | 117<br>119 | 52<br>15 | 30<br>00 | * With land classification added. |
| 75 | Parts of Central and Western Arizona | 1 inch to 8 miles. | 17, 952. 24 | 34<br>35 | 00<br>40 | 111<br>113 | 00<br>45 | 00<br>00 | §Also in geological form, land classification to be added (hachure edition out of print). |
| 76 | Parts of Eastern Arizona and Western New Mexico. | ...do | 17, 952. 24 | 34<br>35 | 00<br>40 | 108<br>111 | 15<br>00 | 00<br>00 | §Also in geological form (hachure edition out of print). |
| 77*b* | Part of Central New Mexico | 1 inch to 4 miles. | 4, 465. 85 | 34<br>35 | 50<br>40 | 105<br>106 | 30<br>52 | 00<br>30 | †Also as land-classification map. |
| 77*d* | ...do | ...do | 4, 510. 27 | 34<br>34 | 00<br>50 | 105<br>106 | 30<br>52 | 00<br>30 | ‡ Do. |
| 78*a* | Part of North-Central New Mexico | ...do | 4, 465. 85 | 34<br>35 | 50<br>40 | 104<br>105 | 07<br>30 | 30<br>00 | * With land classification added. |
| 83 | Parts of Southeastern Arizona, Western and Southwestern New Mexico. | 1 inch to 8 miles. | 18, 301. 78 | 32<br>34 | 20<br>00 | 108<br>111 | 15<br>00 | 00<br>00 | §Also in geological form (hachure edition out of print). |
| 84*b* | Part of Central New Mexico | 1 inch to 4 miles. | 4, 554. 13 | 33<br>34 | 10<br>00 | 105<br>106 | 30<br>52 | 00<br>30 | *‡ In skeleton.<br>Also in hachures with land classification added. |

* To accompany extra copies of annual report, 1879. ‡ Separate edition with annual report, 1878. † Issued with extra copies annual report, 1877. § Accompanying extra copies of annual report, 1876.

NOTE.—The sheets are reproduced as photolithographs in black and underlying tint unless noted otherwise in column of "Remarks."

### RECAPITULATION.

| | |
|---|---|
| Topographical atlas-sheets published | 28 |
| Advancing toward completion and to accompany extra copies of the annual report of this office (herewith) | 5 |
| Land-classification sheets published | 21 |
| Geological sheets published | 7 |
| Total | 61 |

## MAPS (UNPUBLISHED).

### *Geological.*

Contour map of Ely mining district, Southern Nevada. 1 inch = 12 miles. Atlas-sheets, 61 B, 61 C, 70 A, and 70 C., also 52 D, in which more field work is necessary.

### *Special.*

Map of portions of Eastern California and Western Nevada, the Lake Tahoe region of the Sierra Nevada; area, 2,232 square miles; scale, 1 inch to 1 mile, or 1:63360.

Great Salt Lake and vicinity, area 5,719.8 square miles, plotted on scale of 1 inch to 2 miles (more field work required).

### *Topographical atlas-sheets (unpublished).*

| Atlas-sheet number. | Locality. | Scale. | Area, square miles. | Boundaries. |  |  |  |  | Remarks. |
|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  | Latitude north. |  | Longitude west from Greenwich. |  |  |  |
|  |  |  |  | ° | ′ | ° | ′ | ″ |  |
| 20*a* in part. | Parts of Northern Oregon and Southern Washington. | 1 inch to 4 miles. | 3, 859. 85 | 44<br>45 | 50<br>40 | 120<br>122 | 37<br>00 | 30<br>00 | More field-work required (land classification to be added). |
| 20*c* in part. | Part of Northern Oregon | ....do | 3, 914. 30 | 44<br>44 | 00<br>50 | 120<br>122 | 37<br>00 | 30<br>00 | Do. |
| 29*a* in part. | Part of Central Oregon | ....do | 3, 968. 85 | 43<br>44 | 10<br>00 | 120<br>122 | 37<br>00 | 30<br>00 | Do. |
| 29*c* in part. | Part of Southern Oregon | ....do | 4, 022. 58 | 42<br>43 | 20<br>10 | 120<br>122 | 37<br>00 | 00<br>00 | Do. |
| 32*c* | Part of Southern Idaho | ....do | 4, 022. 58 | 42<br>43 | 20<br>10 | 112<br>118 | 22<br>45 | 30<br>00 | Land classification to be added. |
| 38*b* in part. | Parts of Southern Oregon, Northwestern Nevada, and Northeastern California. | ....do | 4, 075. 29 | 41<br>42 | 30<br>20 | 119<br>120 | 15<br>37 | 00<br>30 | Land classification to be added (more field-work required). |
| 38*d* | Parts of Northeastern California and Northwestern Nevada. | ....do | 4, 127. 18 | 40<br>41 | 40<br>30 | 119<br>120 | 15<br>37 | 00<br>30 | Land classification to be added. |
| 41*a* | Parts of Southeastern Idaho and Northwestern Utah. | ....do | 4, 075. 29 | 41<br>42 | 30<br>20 | 112<br>113 | 22<br>45 | 30<br>00 | Do. |
| 47*a* | Part of Northern California | ....do | 4, 178. 42 | 39<br>40 | 50<br>40 | 120<br>122 | 37<br>00 | 30<br>00 | Do. |
| 48 | Part of Central and Western Central Nevada | 1 inch to 8 miles. | 16, 313. 96 | 39<br>40 | 00<br>40 | 116<br>119 | 30<br>15 | 00<br>00 | In hachures only. |
| 52*d* in part. | Parts of Central Colorado | 1 inch to 4 miles. | 4, 228. 56 | 39<br>39 | 00<br>50 | 105<br>106 | 30<br>52 | 00<br>30 | Land and geological classification to be added (more field-work required). |
| 56*b* | Parts of Eastern California and Southwestern Nevada. | ....do | 4, 278. 00 | 38<br>39 | 10<br>00 | 119<br>120 | 15<br>37 | 00<br>30 | Land classification to be added. |
| 56*d* | Part of East Central California | ....do | 4, 326. 29 | 37<br>38 | 20<br>10 | 119<br>120 | 15<br>37 | 00<br>30 | Land classification to be added (more field-work required). |
| 68 in part. | Parts of Northeastern Arizona and Northwestern New Mexico. | 1 inch to 8 miles. | 17, 587. 88 | 35<br>37 | 40<br>20 | 108<br>111 | 15<br>00 | 00<br>00 | More field-work required. |
| 69 | Parts of Southern Colorado and Northwestern New Mexico. | ....do | 17, 587. 88 | 35<br>37 | 40<br>20 | 105<br>108 | 30<br>15 | 00<br>00 | Land classification to be added (more field-work required). |
| 73 in part. | Part of Southern California | ....do | 17, 952. 24 | 34<br>35 | 00<br>40 | 116<br>119 | 30<br>15 | 00<br>00 | More field-work required (land classification to be added). |
| 73*c* | ......do | 1 inch to 4 miles. | 4, 510. 27 | 34<br>34 | 00<br>50 | 117<br>119 | 52<br>15 | 30<br>00 | Land classification to be added. |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 74 in part. | Parts of Southeastern California and Western Arizona. | 1 inch to 8 miles | 17, 952. 24 | 34<br>35 | 00<br>40 | 113<br>116 | 45<br>30 | 00<br>00 | More field-work required. |
| 77 | Central New Mexico | do | 17, 952. 24 | 34<br>35 | 00<br>40 | 105<br>108 | 30<br>15 | 00<br>00 | More field-work required (land classification to be added. |
| 80 in part. | Part of Southern California | do | 18, 301. 78 | 32<br>34 | 20<br>00 | 116<br>119 | 30<br>15 | 00<br>00 | Do. |
| 84 in part. | Part of South Central New Mexico | do | 18, 301. 78 | 32<br>34 | 20<br>00 | 105<br>108 | 30<br>15 | 00<br>00 | Do. |
| 90*a* in part. | Part of Southwestern New Mexico | 1 inch to 4 miles. | 4, 688. 24 | 31<br>32 | 30<br>20 | 106<br>108 | 52<br>15 | 30<br>00 | Do. |
| 90*b* in part. | Part of Southern New Mexico and Western Texas. | do | 4, 638. 24 | 31<br>32 | 30<br>20 | 105<br>106 | 30<br>52 | 00<br>30 | Do. |

## RECAPITULATION.

| | |
|---|---|
| Topographical sheets unpublished | 23 |
| Land-classification sheets unpublished | 12 |
| Geological sheets unpublished | 4 |
| Total | 39 |

NOTE.—Geographical material has been gathered in the following atlas-sheets, but more field-data is necessary before they can be satisfactorily published, viz, 11 C, 20 B, 0 D, 28 D, 29 B, 29 D, 31 D, 38 A, 38 C, 39 C, 39 D, 40 A, 40 B, 40 C, 46 B, 47 C, 51, 56 A, 56 C, 60 C, 60 D, 62 D, 64 B, 70 B, 70 D, 72 B, 72 D, 78 C, 81, 82, 85 A, and 89.

## CONCLUSION AND ESTIMATES.

On December 10, 1878, at the request of the Chief of Engineers, I submitted a memorandum exhibiting the extent, the methods, and the cost of the survey under my charge, and an approximate estimate of the cost of completing it. This appeared as inclosure No. 3 to Senate Ex. Doc. No. 21, Forty-fifth Congress, third session, extracts from which are herewith:

* * * * * * *

The survey at present is carried on at an average cost somewhat exceeding $2 per square mile, and maps of a scale of 1 inch to 4 miles result.

If land classification is to be included, not less than $2.50 per square mile should be estimated. If a triangulation of a higher order of accuracy should be required, the cost of making the same would not be less than $10 per square mile. Such triangulation, however, should not be entered upon until the information gained during the progress of the triangulations of the grades now used to establish check data for a map of 1 inch to 4 miles is sufficient to point the way. The selection of stations for the most perfect set of triangles covering this entire area can only be made with a proper degree of intelligence after the marked topographical points have been occupied as triangulation stations, and observed at with the degree of accuracy now required.

It is thought that the amount of $2,039,522.50 is the minimum of expense that should be anticipated for the completion of the survey required for a topographical map on a scale of 1 inch to 4 miles.

* * * * * * *

Since it appears that the interior topographical surveys on the European continent have cost, as in the case of Prussia, $65 per square mile as a minimum, and in England $190 per square mile for its ordnance survey, it can be readily seen how much skill and judgment should be displayed in the detailed plans for all branches of the field and office work; how much prudence in the administration and facility in the execution of so important a trust as the prosecution of a connected topographical survey of large interior areas.

The best distribution of the amount of, approximately, $2,000,000 of appropriation would be over an interval of fifteen years, somewhat as follows:

| | |
|---|---|
| Three years, $120,000 | $360,000 |
| Three years, 125,000 | 375,000 |
| Three years, 135,000 | 405,000 |
| Three years, 140,000 | 420,000 |
| Three years, 150,000 | 450,000 |
| Total | 2,010,000 |

Larger amounts could not be used with a due regard to economy, because of the want of skilled assistants. The number of really effective working parties can be but slowly increased, since a special field training is requisite to perfection in the application of the methods.

The plan now pursued in the topographical surveys west of the 100th meridian is to confine the parties engaged in field-work to a part or all of one of the rectangular divisions of the area, of which there are ninety-five, as shown upon the progress map.

Each of these divisions, when represented upon a scale of 1 inch to 4 miles, requires four sheets of 19 x 24 inches. The secant-conic projection employed, the co-ordinates of which are the result of original computations at the office of the survey, admits of the conjoining of the sheets, and demands uniformity in size as a prerequisite. The approximate size of the area embraced in the average atlas-sheet is 150 miles in longitude by 120 miles in latitude, or in square miles, approximately, 18,000, corresponding 11,520,000 acres.

* * * * * * *

The final topographical sheets represent mountain forms by hachures alone, or by a combination of hachures and contours.

The land classification, including arable and arid, timber and grazing, together with marked outcrops of precious and economic minerals, is similar to the expression of geological formation shown upon the topographical sheets in colors (see Annual Report Chief of Engineers, 1878, Appendix N N, p. 1439).

The land classification, as well as the topographical map, should finally be made complete for the entire area. The government will then become possessed of sufficient data by means of which to define by law a new disposition of its lands to settlers.

The main portion of the work is in advance of the subdivisions of the public lands, for the purposes of occupancy and sale; still, connection may be had with the meridian, base, and township lines of these surveys, and the true longitude and latitude of at least one given township corner to each county may be furnished the General Land Office as a check. The law might recognize the use of these points geodetically determined as proper checks in the land-parcelling surveys.

The gauging of streams at marked points of their flow is now going on, and there should be added the requirement of connecting by levels of precision sub-basins of drainage, thus to determine series of datum points to which to refer the profiles of the irrigating channels, when the same may be constructed.

As the scale of the map of the public domain may be directed to be increased at any time by Congress, it must be understood that a *pro rata* increase of expense will ensue, on account of more details as to triangulation, and for minor topographical measurements. At present more detailed topographical data is being secured at prominent mining districts, and in the more thickly settled areas, and at a cost for actually occupied square miles greater than that herein shown. The field-record forms and computation blanks in use by the survey have been adopted, after much deliberation and forethought, and exceed thirty in number. A manual of meteorological observations has been issued, and one for the geodetic and topographical observations and reductions is being prepared.

An adequate appropriation will admit of winter and summer parties, thus keeping a permanent expedition in the field until the whole area is covered.

The *personnel* engaged includes officers of the Corps of Engineers and other branches of the Army; certain technical civilian assistants and scientists; assistants enlisted in the general service; and there should also be added a number of enlisted men of the Engineer Battalion. The Washington office should be confined to the reduction of the field plots, and the issue of the maps and annual reports of operations.

* * * * * * *

Congress evidently did not consider the above estimate at that session, since in establishing the "Geological Survey," none of the duties of a topographical or geographical survey were confided to the direction thereof, but, to the contrary, the word "geographical" was stricken from the law. A geographical survey presupposes that a topographical map has been or is to be made, upon which to delineate cartographically a portion of the results. The requirement for a connected topographical map in detail of over 800,000 square miles of mountainous area, remaining unserveyed at the West, for the uses of the War Department alone, is even more apparent now than when the subject by request was laid before the House Committee on Appropriations in April, 1872; and yet at the close of the present fiscal year, for the first time since the earliest appropriation for the Pacific Railroad surveys (winter of 1852-'53), the War Department is found without money for its usual topographical surveys, as the funds of the last of twenty-eight separate appropriations made during and since that interval cease to be available after June 30, current.

It would seem that no other department, should the jurisdiction finally be lodged with it, would have the same interest in sending at an early day parties to prosecute topographical surveys in the outlying and most inaccessible parts of this great area.

As bearing still further upon the cost of this work, a copy of my letter of February 20, 1879, is here introduced, that, having been submitted by the Acting Chief of Engineers to the War Department, was forwarded and appeared as House Ex. Doc. No. 104, Forty-fifth Congress, third session:

WAR DEPARTMENT,
*Washington City, February* 24, 1879.

The Secretary of War has the honor to transmit herewith, for the consideration of the Committee on Appropriations, a communication received from the Acting Chief of Engineers, submitting statement in regard to the total amount expended in the prosecution of military and geographical surveys west of the one hundredth meridian now being carried on by this department.

Very respectfully, your obedient servant,

GEO. W. MCCRARY,
*Secretary of War.*

The SPEAKER *of the House of Representatives.*

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST ONE HUNDREDTH MERIDIAN,
*Washington, D. C., February* 20, 1879.

SIR: I have the honor to invite the attention of the department to the following remarks of the Hon. J. D. C. Atkins, chairman of the Committee on Appropriations of the House of Representatives, made while the legislative appropriation bill was under consideration in the Committee of the Whole House, in order that any erroneous impressions that might be derived therefrom shall be corrected.

The following appears as a portion of his remarks in the Record of the 11th instant, page 31:

| | |
|---|---|
| "United States surveys and explorations west of the one hundredth meridian, Lieut. George M. Wheeler in charge, 1869-'79 | $549,316 |

"General Humphreys does not report the salaries of officers, soldiers, and detailed men from other departments, and other sources of expenditures. If these were included it doubtless would raise the amount to over $1,500,000."

Referring to House Ex. Doc. 88, Forty-fifth Congress, second session, it appears that the One Hundredth Meridian Survey had expended up to March 8, 1878, as follows:

| | |
|---|---|
| From Engineer appropriations | $368,770 55 |
| Aid and supplies from Quartermaster's Department | 121,348 00 |
| Aid and supplies from Commissary of Subsistence | 5,135 54 |
| Aid and supplies from Ordnance Department | 4,062 63 |
| Total to that date | 499,316 72 |
| Amount appropriated for the fiscal year ending June 30, 1879 | 50,000 00 |
| Total | 549,316 72 |
| Salaries of officers since commencement, to include February 14, 1879 | 66,828 13 |
| Total | 616,144 85 |
| Amount stated by Mr. Atkins | 1,500,000 00 |
| Difference | 883,855 15 |

The officers performing professional services, their salaries are properly chargeable to the total cost of the survey. The "soldiers" are paid the same, whether detailed as escorts upon this work or not, nor are they diverted, except temporarily, from their usual field of duty; and they do not add to the aggregate of results, but on the contrary, by the necessity of their presence, prove that the labors are conducted in the face of more than ordinary obstacles. Their expense has not, therefore, been considered properly chargeable to the work.

No men have been detailed from "other departments."

It is not known by "other sources of expenditure" to what allusion is made.

Farther on in his remarks upon the subject of surveys Mr. Atkins states as follows (see Record of the 19th instant, page 85):

"And we appropriated, I believe it was, $100,000 for the Wheeler survey, besides the transportation that is furnished to Lieutenant Wheeler by the War Department, which amounts to as much more."

The amount actually appropriated and as shown above, for the year ending June 30, 1879, was $50,000, instead of $100,000. While it is impossible to furnish the exact amount paid for transportation since March 8, 1878, as the field accounts are not yet all at hand, still the approximate amount paid by the Quartermaster's Department for this purpose, to include January 31, 1879, is not to exceed $24,000.

Instead of $200,000 for the year in question, as would be inferred, the summation of the appropriation and cost of transportation is not to exceed $74,000.

I have the honor to request that the information contained in this statement may be forwarded.

Very respectfully, your obedient servant,

GEO. M. WHEELER,
*First Lieutenant, Corps of Engineers, in charge.*

Col. H. G. WRIGHT,
*Acting Chief of Engineers, U. S. A.*

[First indorsement.]

OFFICE OF THE CHIEF OF ENGINEERS,
*Washington, February* 20, 1879.

Respectfully submitted to the honorable the Secretary of War.

H. G. WRIGHT,
*Acting Chief of Engineers.*

Independent of the great value to the War Department of constantly improving detailed maps for its current uses, the resulting advantage to its officers engaged upon these surveys lies in the experience gained with men and affairs, and in studying the *terrain* within the field of vision, from actual measurements made of roads, trails, streams, and relative elevations, thereby educating that "*coup d'oeil*" so essential to the commander in time of war, and which has been considered of great importance in foreign countries, and should not be lost sight of in our own.

## ESTIMATES.

For the preparation, under the direction of the Secretary of War, of reports and maps, and such other illustrations as may be necessary in completing the office work of the geographical and topographical survey of the territory of the United States west of the 100th meridian, including cost of engraving and printing, thirty thousand dollars, to be immediately available.

To be expended somewhat as follows:

| | |
|---|---|
| For office expenses, including pay of assistants | $19,500 00 |
| For storage | 500 00 |
| For engraving and printing maps and charts | 8,000 00 |
| For preparation, engraving, and printing plates, cuts, photographs, and other illustrations | 1,000 00 |
| For office contingencies | 1,000 00 |
| | 30,000 00 |

It is estimated that for filling gaps in the triangulation and topographical work, thereby admitting of the completion and publication of a number of atlas-sheets, a like amount will be sufficient.

## FINANCIAL STATEMENT.

| | |
|---|---|
| Amount expended from appropriation for the fiscal year ending July 1, 1879. | $48,414 59 |
| Amount remaining unexpended July 1, 1879, from appropriation for continuing the office work of the geographical surveys of the territory of the United States west of the 100th meridian for the fiscal year ending June 30, 1880 | 20,000 00 |

Respectfully submitted.

GEO. M. WHEELER,
*Captain of Engineers, in charge.*

Brig. Gen. H. G. WRIGHT,
*Chief of Engineers, U. S. A.*

## APPENDIX A.

### REPORT OF LIEUTENANT S. E. TILLMAN, CORPS OF ENGINEERS, IN CHARGE OF PARTY NO. 1 UTAH SECTION, FIELD SEASON OF 1878.

WASHINGTON, D. C., *March* 31, 1879.

SIR: I have the honor to submit the following report upon the operations of the party under my charge during the field season of 1878, together with a brief description of the country visited and a statement of present condition of office work.

I left Washington July 19 and reached Ogden on the 24th. At this point the outfits for three parties were collected. Indian troubles in Idaho prevented the field work from being conducted to the northward from Ogden, as was originally intended. The parties were organized at Ogden and transported by rail to the vicinity of the new areas selected. The area chosen for the operations of the party under my charge is in atlas-sheet 47*a* of progress map, and is situated between the parallels of 39° 50′ and 40° 40′, and the meridians of 120° 37′ 30″ and 122° 00′ 00″. It lies to the westward of and contiguous to areas mapped in 1876 and 1877.

Chico, a town on the California and Oregon division of the Central Pacific Railroad, was chosen as a base of operations, and here the supplies were collected. The party as organized consisted of myself, in charge, Mr. Gilbert Thompson, principal assistant and topographer; Mr. J. S. Polhemus, assistant topographer; Mr. Louis Seckles, meteorologist; Mr. John Bishop, odometer recorder; one enlisted man, two packers, and a cook. Before my arrival at Ogden, Mr. Thompson, with a packer and the soldier, had been sent out towards Bear Lake, for the purpose of obtaining the data necessary to complete an atlas sheet of the previous season. With the exception of that portion in use by Mr. Thompson, my outfit left Ogden on July 27 by freight. Mr. Thompson, with remainder, left on August 1. On August 8 everything had reached Chico, and on the morning of the 9th the rendezvous camp was left for the field, the party taking thirty-five days' rations.

The country to be mapped lay principally in the Sierra Nevada Mountains, but at the southwestern corner extended a few miles into the Sacramento valley. The limiting line on the west, for the greater portion of its length, fell in the foot-hills of the Sierras. Chico was a little way outside the area. In starting from the rendezvous camp it was my intention to make the complete circuit of the area, accomplishing as much as possible from a single line and obtaining a definite idea of the country. With this intention the party moved along the southern limit of the sheet until reaching the North Fork of Feather River. At this point the cañon of this stream could not be crossed and a long detour to the south had to be made. The crossing was effected at Oroville, and the stream was ascended until the original line of travel was reached and resumed. The physical features of the country caused me to abandon the idea of a reconnaissance trip around the entire area. The accompanying topographical sketch shows the lines of travel, and from the consecutive numbers of the camp the direction of the travel is known. The principal points occupied for topograpical and geodetic purposes are also indicated on the sketch.

Chico was revisited September 11 for supplies. Between the dates of leaving and return to Chico 22 camps were made and two approximately parallel lines of travel were run, extending from Chico to the eastern limit of the work. The party left Chico the second time on September 14, with 20 days' rations, and supplies for 40 days were at same date sent to Prattville by wagon Reference to the sketch will again show the lines and direction of travel, the principal topographical stations, and the places named. The party reached Prattville on September 26, and made it a base of operations from that date until October 16. On October 3, a portion of the party, under charge of Mr. Seckles, was left in camp at Prattville, the remainder operating in the direction of Lassen's Butte. The small party at Prattville made hourly readings of the barometer from 7 a. m. to 9 p. m. daily, from the 3d to the 13th of October. On October 16 the party left Prattville for the last time, taking the supplies left at that date. The general movement was thence to Greenville, Taylorville, and Susanville.

The successive camps and subsequent movements of the party are shown on the sketch, and any other remarks upon them are deemed unnecessary. Susanville was reached October 23. Camp 63, opposite Red Bluff, was made November 14, and Chico was reached December 5, where the party was broken up. The natural and physical features of the section made it a difficult one to examine with satisfaction. Nearly the entire surface is covered with timber or underbrush, which renders observation for topographical purposes, except from the most prominent points, very difficult. The lack of distinctly marked and naked points rendered it necessary to fix most of the topographical stations by observations from them, the observations to them being generally uncertain. The sketch is intended to convey an idea of the work done. The streams are pretty fully shown; the full lines are measured meandered roads; where there are dotted lines no roads existed. When such lines are along trails, it is indicated. For the reasons already given, much was made to depend upon the meandered lines. Every line of this sort which would give a reasonable amount of topography was run. From the topographical stations, the usual full sketches were made. The triangulation was an extension of that of 1876 and 1877.

There were occupied for topography and located by observations on known points 50 stations; eight of these were meander stations also. There were made 5,167 meander stations, from many of which more or less extended sketches were made. One thousand three hundred and twenty-one miles were meandered and 965 traveled, not meandered. Sextant altitude observations were taken at 15 camps. Observations for altitude of 136 points were made with cistern barometer and 1,129 with aneroid. The aneroids, except upon a few occasions, were compared tri-daily with the cistern. The variation of the needle was determined at 30 points.

In accomplishing the results here given, 108 days were occupied in actual field work. Stormy weather delayed the party 10 days, and 10 other days were occupied in camp transcribing and arranging collected data. In addition to the above, Mr. Thompson accomplished 9 days' field work and 2 of camp before joining the party at Chico.

The party was provided with the usual allowance of instruments, to wit: 1 sextant

and horizon; 1 triangulation instrument—10 inch, by Stackpole; 2 topographer's transits—minute instruments; 2 cistern barometers; 2 aneroid barometers; 2 psychrometers; 1 maximum and minimum thermometer; 2 pocket thermometers.

In closing this portion of the report, it gives me pleasure to certify to the zeal, energy, and fitness of my assistants. Mr. Thompson has accompanied me in the same capacity for three successive field seasons. His interest in every detail of the work, his untiring energy, long experience, and familiarity with the work I have each year testified to. Whether engaged upon triangulation, topographical, or meander work, I believe that he always accomplishes the best results at the least expenditure of time and labor that his means allow. Mr. Polhemus came to the field familiar with the instruments but unacquainted with the kind of work. He acquired with marked rapidity a knowledge of the requirements of the work, and his interest and energy made him a most valuable assistant. Owing to the capacity of these two assistants we were often able to have all three of the topographical instruments in operation at once, and very frequently indeed two of them were being used. The party was thus able to accomplish far more than the addition of a single assistant would seem to imply. Mr. Seckles, in addition to the ordinary duties of the meteorologist, kept the aneroid and odometer record. He was faithful, conscientious, and intelligent in the performance of his work, and the full value of his services were not appreciated until his work came to be reduced.

The country embraced in the sketch lies principally in the Sierra Nevada Mounains. The true summit line of the mountains is shown, as also the terminating line f the western foot-hills. The distinctly marked eastern wall of the mountains disppears at Thompson's Peak, near Susanville. The range is broken into numerous cones nd confusing spurs. The northwest section was once the seat of intense volcanic tion, and is dotted with ancient craters—the most marked being that of Lassen's tte, which has an altitude of 10,400 feet, and stands 1,000 feet above any point ithin 75 miles. From the bordering lines of the foot-hills in the Sacramento alley long spurs of even grade extena to the northeast. The highest points of these urs form a line called the western summit. This line, so far as our work is conrued, culminates at Lassen's Butte. South of this point the western summit line is rtuous, its general direction being a little east of south. Between the two summit es are situated several small valleys, the most important of which are the Big Meadrs, Indian Valley, American Valley, Mountain Meadows, Butt Valley, Deer Creek adows, Battle Creek Meadows. The little town of Prattville is at the southern end Big Meadows. There are several stores and a hotel at this place. It is largely ited in summer by the residents from Sacramento Valley, and affords a delightful nge from the oppressive heat of that valley. The extent of the valley is approxtely outlined on the sketch by the loop formed by the roads from Prattville around camps 35–48 and back. Taylorville is the settlement of Indian Valley, and is at its thern point. The loop of roads from the village to camps 44–43 and return shows extent of the valley. Quincy, the county seat of Plumas County, is situated in erican Valley. This valley is much smaller than the other two mentioned. The ntain Meadows are north of Greenville, and are completely outlined by the line of vel starting from camp 48*a* and return. Camps 41 and 18 mark the southern end of all valley called Butt Valley. It extends 5 or 6 miles up the creek there indid and varies one-fourth to a mile in width. An open area extending a couple of s on either side of Longville is called Humbug Valley. Deer Creek and Battle k Meadows are situated near the heads of those creeks. Camp 29 is at the upper of the first-named, and camp 58 the lower end of the second.

the Big Meadows, Indian, and American Valleys the cereals and different kinds egetables are successfully grown and some fruit. Butt and Humbug Valleys and Mountain Meadows have permanent occupants, who succeed in growing a few tables, but who mainly depend upon their cattle ranches. All the valleys named ort herds of cattle in summer and yield quantities of hay for their sustenance in r. The waters from these mountain basins pass by deep and picturesque cañons e Sacramento Valley. Along the courses of these streams, above the scorching of the Sacramento Valley and below the mountain snows, are situated several and prosperous farms. For the greater portion of their lengths these cañons are n and desolate, and will forever remain so. The natural scenery of the region, ally around Lassen's Butte, is seldom surpassed. From this lofty cone the waters in every direction. On its south side, at an altitude of about 7,000 feet, is situa beautifully clear lake. From this lake, by an almost precipitous fall, the water nds for 1,000 feet. Rushing on in its downward course, it passes through a region t springs. The whole surface of the ground in the vicinity of these springs is . The cold water from above, reaching these heated points, is partially converted team, which in its efforts to escape sustains an almost continuous column of wathe air. In some places the generated steam is recondensed without reaching the e, so that beneath the surface appear innumerable little jets in continual activity. The temperature of the stream before reaching this caldron is 51°; after passing through it is 85°.

The view from this point is particularly fine. On either side the lava-capped ridges rise up 1,500 feet, and to the north Lassen's Butte extends upward 2,000 feet more. Many other vents existed through which vaporized bodies made their escape. Some are still feebly active, and far up the cañon sides are seen, in variegated colors, the effect of the heat upon the volcanic rocks. From the springs there continually arises a dense column of fine white steam, which contrasts beautifully with the dark green pines, the bright earth, and sombre-colored rocks. From this point the stream, Mill Creek, continues to the southward for six miles and then turns to the westward and passes to the Sacramento through a grand cañon, reported to be impassable. On a line nearly due east from the springs just mentioned are situated several such springs, the nearest batch being upon the surface of the eastern wall of the cañon, about 1,500 feet above. Still farther to the east, and in the cañon of Warner Creek, is a large number of these springs. More to the east, and in the same line, is a hot lake, heated by the escaping steam which is generated under pressure at lower depths.

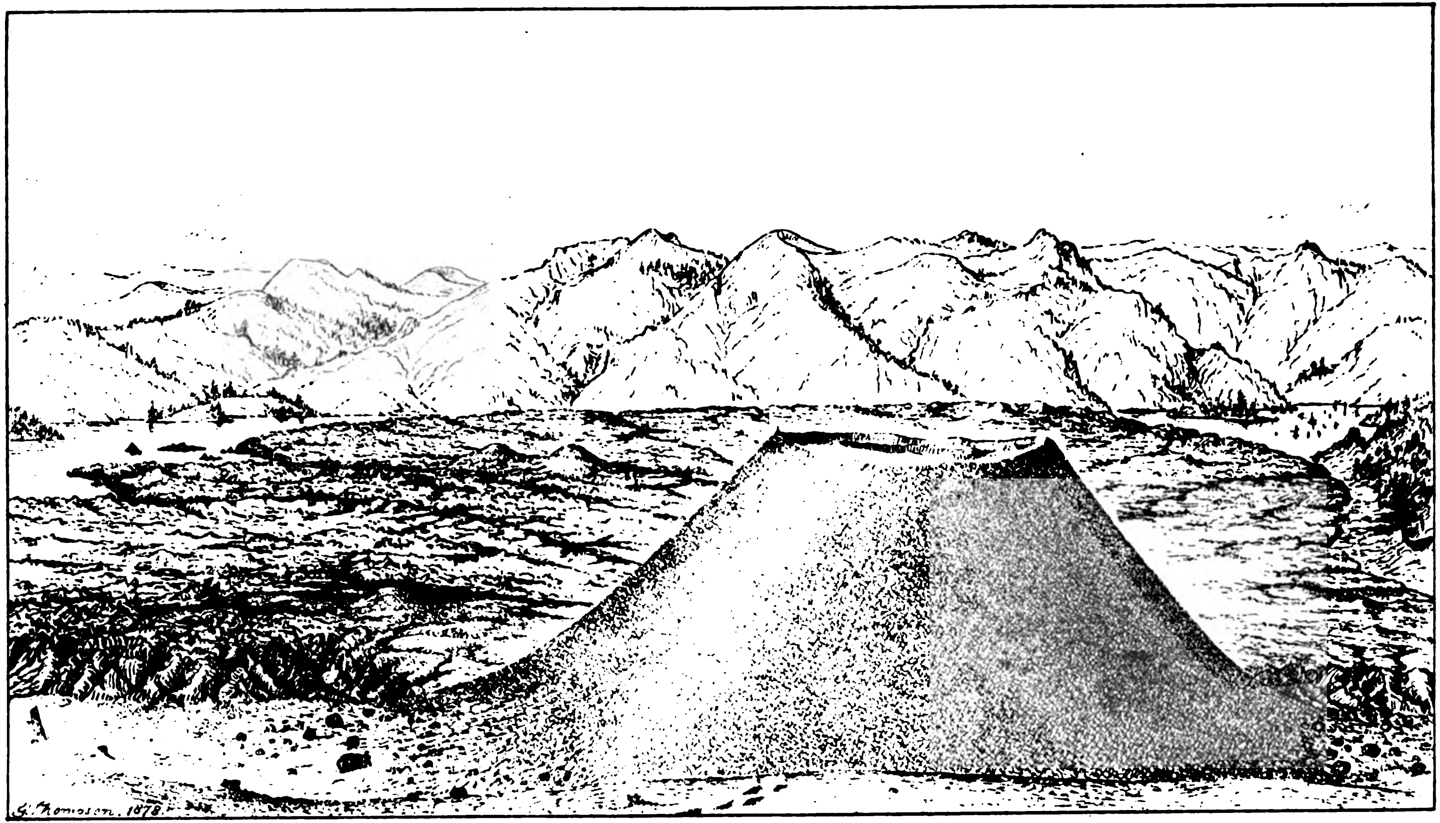
The most easterly of these springs is just north of Willow Lake on the sketch, between camps 31 and 32. This is situated at the head of a small gulch. A circular basin of about 15 feet diameter receives the percolating waters from the surrounding sides. Under this basin superheated steam is generated, which, escaping, keeps the water in continual agitation. At the time of our visit the water at one point was thrown to the height of 5 feet, the entire basin being at the boiling temperature. From all accounts, the action is continually growing less energetic. At all of these springs the action in decomposing the surrounding rocks is seen; some of them, from the continual agitation of the waters wearing away the surrounding sides, have reached a ropy consistency. After reaching this state, whenever the uplifted waters fall beyond the basin the suspended material is again deposited, so that around many of the springs little craters are built up.

Lassen's Butte is the center of this disturbed region, and, owing to its separation from other high points, is very prominent. It is easily ascended by the southeast spur. The party visited it on the 6th of October. A more fitting day could not have been chosen. It was immediately subsequent to a storm, and the atmosphere was clear and still. Mount Pitt on the north and Mount Rose on the south could be distinctly seen. Mount Shasta, though 70 miles away, did not appear half that distance. The meadows and flats of the mountain region and the Sacramento Valley were all open to inspection. Their famished vegetation lent at the distance a pleasing effect to the view. The point is itself an extinct crater, and from it many others were seen. One of these, the most recent, is worthy of mention, and is shown in the sketch. The cone is a perfect specimen. It is about 475 feet high, and is composed of black, granular cinders. The slopes are very steep—about 45°—and the ascent difficult. Upon arriving at the upper rim the interior is seen to consist of a double funnel. The larger funnel extends about 30 feet downward and then a second rim exists, which is the base of the smaller funnel. This funnel is about 150 feet deep and to the eye symmetrical.

At the south point of the circumference of the base of the cone there exists a sort of arched opening, displaying the black lava which underlies the cinders. From this point the rigid curves in the lava still show the direction of the flow, which was first to the south and then to the east. The extent of the flow is about three-fourths of a mile wide and one and one-half miles long. The field is of indescribable roughness. The flow terminates in an abrupt wall about 100 feet high. The whole mass is so rough, broken, plowed by ravines, uplifted by bubble-like protuberances, that it becomes beautiful and grand from its utter desolation. All the eastern side of the lava flow is bordered by a lake, which evidently existed before the outburst. It is divided nearly in two by the lava. Looking from the point upon which the sketch was made the whole picture is peculiarly fine. In the foreground is the cone of cinders, a perfect frustum; the lava from it spreads in bleak desolation around its base; the dark blue waters of the lake make a border around the lava; then the many shades of green from the mountain sides beyond complete the strange and weird picture. Dead trees are still standing in the lake, which probably only reached them after the eruption.

At the southwestern base of the cone are a number of globular concretionary masses, a sort of volcanic bullet, of a dark, liquorice color, containing white quartz-like crystals, probably analcime or leucite. A few fine bushes have found root in the lava within the past ten years, but by the ordinary observer these are overlooked, and it appears perfectly barren.

The cone here mentioned is the most recent, but the action of many others of older date has been more powerful. To the eastward and northward the craters are very numerous, and they rise in close proximity. In the basins between them the waters from the melting of the accumulated snows of winter collect and form lakes. From one point I counted twenty-two lakes, varying in area from 3 square miles to as many acres. These lakes are the source of many bountiful springs, which burst forth in the


G. Thompson. 1878.

CINDER CONE. LASSEN Co. CAL.

Long. 121° 19′00″ Lat. 41° 32′ 40″ approx.

ALTITUDE 6906′

mountain valleys to the south. The valleys, flats, lower cañons, and foot-hills of this section afford good grazing; the greater portion of the mountain region and upper foot-hills are timbered or covered with chapparal, and grass is scarce. Cattle and sheep are driven here from the Sacramento Valley during summer, and the entire area is tested to its utmost limits to support them.

The vegetation of this region has been twice described in survey reports—first in the survey for a Pacific railroad in 1854, and later, in the geological survey of California. The valuable timbers are the different varieties of pine. Near the head-waters of Chico, Antelope, and the northern tributaries of Battle Creek are situated numerous saw-mills. It would be difficult to find a region better suited to the production of lumber. Its transportation is, however, attended with much difficulty. It is carried to the valley both by flumes and wagons. The construction and repair of flumes make them very expensive, and transportation by wagon is difficult and tedious, owing to rough roads and steep gradients. Some of the flumes are thirty miles long and in many places have to be supported by expensive trestle-work.

The general geological features of the section may be briefly stated. From Lassen's Butte as a center, a vast sheet of lava has flowed in every direction. It covered nearly all the western slopes of the Sierras, extending (as far down as Red Bluff) to the Sacramento River. South of this point the lava did not reach to the river. The southern point of this sheet is near Oroville. To the east the lava extended to Susanville. The limit of the flow from this point is made by a line (on sketch) passing through camps 48, 48*a*, 48*b*, 34, 42, 28, 27, 19, 21, 3, and 6. Before the western slopes of the Sierras were covered by lava there was deposited a layer of conglomerate composed of fragments of metamorphic rocks. In many places this conglomerate is now exposed, and a fact which at once strikes the attention is that at the time the conglomerate was formed the gradients must have been very different from the present. The size of the matrix stones is such as to show that with the present slope they could not have been brought into position by present causes. In some places—as between Butte and Chico Creeks—the lava has not covered the conglomerate, and the sedimentary deposits are seen in several layers Beneath the conglomerate, Tertiary and Cretaceous beds were exposed in some of the cañons. Granite appears along a line from camp 5 to 6, and from camp 9, along a line, to Greenville. It also appears in the vicinity of camp 45 and is exposed in a narrow belt from that point to the southeast.

South of Greenville there is a quartz mine in operation, which I visited. The superintendent was unwilling to give any information in regard to the mine, but referred me to the owners in San Francisco. There is another mine in the same vicinity in operation, but it was not visited. Copper and iron ores were seen in the vicinity of camp 45, and prospecting is carried on in the granite ledges extending from that point along the line above indicated. Hydraulic mining and prospecting have been extensively attempted between camps 5 and 6. Sedimentary rocks of the Pliocene period make up the remainder of the exposure of the section embraced in the sketch. Around Lassen's Butte the evidences of glacial action are very distinct and beautiful. To the north and east of the butte the lava covering is continuous. The more recent flows can be easily distinguished from the older. In one place along the old emigrant road, north of Lassen's Butte, the lava crust has broken in, exposing an immense arched cavern. It would seem that the upper surface had cooled while the interior was still liquid. This liquid subsequently flowing out left the opening. Far down on the western slopes of the mountains are situated several extinct craters. The lava-fields from Oroville to the north are principally hard basaltic lava with occasional layers of ashes and scoriæ. Lassen's Butte is a magnificent mass of trachytic *débris* with projecting ledges of the same. It was once a crater. Rhyolite is found at the south and eastern base of the butte, which at a distance closely resembles gneiss.

It is well known that it seldom rains in this section between May and November. At the time the party left Chico, August 8, the Sacramento Valley was oppressively warm, parched, dusty, and disagreeable. The day temperature frequently exceeded 100°, while the night temperature was 30° to 40° less. The daily range in the valley was not so great as in the mountains, though the daily maximum and nightly minimum of the valley were both greater. The valley of the Sacramento, as viewed from the mountains between August and December, is generally enveloped in haze. This haze is so much thicker in the valley than above that it is outlined like a wall both horizontally and vertically. It was a source of much trouble in topographical and geodetic observations. The obstructions to the work from this cause, from the timber, and from the long, deep cañons, made the area difficult to map with accuracy.

The accompanying sketch is intended to render intelligible the movements of the party, and give an approximate idea of the labor bestowed in the work. I am indebted to Mr. Thompson for the topographical sketch, as well as the drawing of volcanic cone herewith.

In conclusion, I would refer to the obliging kindness of General H. B. Davidson, agent of the Central Pacific Railroad at Chico. His disposition to assist the party greatly facilitated our preparations, and saved me great personal annoyance.

After reaching Chico, on December 5, the party was disbanded. The material and animals were taken to Sacramento. I was detained at this place until the 18th of December, in connection with the disbandment of the parties of Lieutenants Macomb, Young and Ludlow. On the 20th I arrived at Ogden, at which point I remained eight days, under your instructions, for the purpose of starting a field office at this point. On the 28th I left Ogden for Washington, and arrived here on the 2d of January.

### OFFICE-WORK.

Upon arriving at the office I was directed to superintend the reductions of geodetic, topographical, and hypsometric observations. As usual, the amount of work in these reductions has been very great. In the geodetic branch Mr. Miles Rock is the first assistant. At the time of my arrival he had the work well under way. He has practically had charge of its execution since, seldom receiving any advice from me except as to order of sequence. He has selected and arranged the figures for adjustment, and been employed principally upon the computations for adjustment. His thoroughness, great care, and perfect system are all that could be desired in such work. For the management of this branch of the work he deserves and should receive the principal credit. In this branch the other assistants have been Mr. J. S. Polhemus, Mr. C. J. Kintner, and Mr. William Hoffman. Mr. Polhemus commenced the work upon his return from the field, and has been continuously engaged upon it since, having had experience in every step, from the adjusting of angles to the final computation of positions. He has been very regular in attendance, careful and systematic, and perfectly satisfactory as an assistant. Mr. Kintner was employed temporarily, and was engaged in the adjustment of figures and subsequent computations. He brought his previous experience to and displayed his usual rapidity in the work and greatly facilitated the reductions. Mr. Hoffman's services were secured about the middle of January and retained since. He has taken part in every step of the reductions, from the station adjustment to the determination of the final position, and his work has been satisfactory. Dr. A. Einhorn was also employed a few days in this branch of the work. In the meteorological branch Mr. F. M. Lee and Mr. F. W. Floyd and Mr. John Hasson have been the only assistants. Mr. Hasson was employed only temporarily. Mr. Lee has been engaged entirely in the arrangement and computation of observations from the cistern barometer, and Mr. Floyd entirely in the computation of aneroid profiles. These gentlemen are neat, careful, and conscientious in their work, and it is sufficient commendation to call attention to the results as below stated.

In the geodetic branch at the time of writing (April 15) there have been computed the positions of 46 primary triangulation stations, 30 secondary triangulation stations, 31 cross-sight stations, 120 three-point stations. In the meteorological department there have been computed 805 altitudes from cistern barometer observations, 5,443 from aneroid observations.

Very respectfully,

S. E. TILLMAN,
*First Lieutenant Corps of Engineers, U. S. A.*

Capt. GEORGE M. WHEELER,
*Corps of Engineers, in Charge.*

## APPENDIX B.

### REPORT OF LIEUTENANT T. W. SYMONS, CORPS OF ENGINEERS, IN CHARGE OF PARTY NO. 1, CALIFORNIA SECTION, SEASON OF 1878.

UNITED STATES ENGINEER OFFICE AND OBSERVATORY,
*Ogden, Utah, March* 31, 1879.

SIR: I have the honor to submit the following executive and descriptive report of the operations of the party under my charge during the field season of 1878.

I arrived at Carson City, Nev., on the 12th day of July, under orders to organize there for the field two topographical parties and one geological party. Owing to delays in forwarding supplies and assistants from the east, it was not until the 29th day of July that I was able to leave Reno with men and instruments to rendezvous at Camp Bidwell, where I arrived August 1. August 4, our stores arrived, and on the 7th, everything being in shape, we started for our summer campaign with the following *personnel* and outfit: Lieut. Thomas W. Symons, Corps of Engineers, executive officer and field astronomer; Charles P. Kahler, topographer; Thomas W. Goad, meteorologist and assistant topographer; H. W. Henshaw, naturalist; Richard Pitcher, odometer recorder; French, Sayres, Collins, and Barrett, packers; and Willson and Henderson, cooks.

Our transportation consisted of 11 riding mules, 16 pack-mules, 7 extra mules, and a bell-mare and colt. A full set of the instruments, books, &c., necessary for our work was furnished. Our instrument for taking azimuths was, however, too old and worn to be reliable for that purpose. It was my intention, if possible, to carry a system of triangulation across from the mountains occupied in 1877 by my party, in the vicinity of Surprise and Warner Valleys, in a northwesterly direction, to the high peaks of the Cascades. This I found to be entirely impossible in the time at my disposal, owing to the dense haze which prevailed almost uninterruptedly from the time of leaving Bidwell until we reached the vicinity of Mount Jefferson, in the fall.

The people of the country inform me that it is generally very hazy during the summer in Oregon, but that for some reason it was much more so this summer than ordinarily. This haze must be attributed mainly to the fires in the woods and swamps, of which great numbers came under my personal observation, and these formed but a small part of the existing ones. Besides those which occur from unexplained causes, great numbers of these fires are built by the Indians for the purpose of driving game into places convenient for their slaughter. They also burn off the marshes in the latter part of the summer, that a more tender and nutritious grass may grow for their ponies. The haze is also very largely attributable to the impalpable dust which rises from the desert. The winds grind the dry, cinder-like vegetation of the great arid plains and mountains to atomic fineness, and then, carrying it aloft, it mingles with the smoke and forms the impenetrable clouds which so seriously impede the work of the surveyor.

Our first station after leaving Camp Bidwell was Sugar Loaf Mountain, a triangulation station of the previous year. Leaving this we went around to old Camp Warner, and then moved to the north. On Rabbit Creek we found a deserted cabin, and quite a large number of cattle and horses which had undoubtedly been deserted by the owners for fear of the Indians who had devastated portions of Warner Valley, only a short distance away.

Bidding adieu to Rabbit Creek and its myriads of little scampering inhabitants from which it takes its name, we crossed a range of hills where bunch grass and springs could furnish food and drink for many cattle, and then on to the north across the great arid rocky plateau lying to the east of Abert Lake. So rocky and barren is this great plateau that not a living thing was seen during our journey across it. In the distance we could see the outlined mass of a mountain, which guided us and which I wished to occupy if the haze should diminish sufficiently. Arriving near it toward nightfall we spread out in search for water, but the hillsides and ravines, so far as we could find, were as innocent of water as are the mountains of the moon. After traveling some time into the night, we found a place where a little water could be dipped up from about the roots of the tules, and here we made camp and passed a night made hideous by the bites and songs of myriads of mosquitoes, the wailing cries of the coyotes, and the stifling atmosphere.

As early as possible in the morning we moved out to the westward, and after traveling several miles found a beautiful spring in the northwestern part of the valley, where men and animals slaked their raging thirst, and then keeping on to the westward over a rolling sage-brush country utterly desolate and waterless, we at last, at nine o'clock in the evening, reached Chewaucan marsh and camped on the banks of the Chewaucan Creek.

This marsh or valley is divided into two parts very similar, and separated by an intervening range of hills, except at the low place where the stream breaks through. They are both low and marshy, and overflowed in the spring, and while a small proportion has been reclaimed, by far the larger part is still a tule and marsh grass flat, furnishing a good winter range for cattle that live on the hills in the summer. The Chewaucan flows through these two divisions, not as a stream, but by being disseminated through them to form the marsh, and then leaving as a creek to flow into the south end of Abert Lake, which is its sink. Some ranches have been taken up and worked where there are streams coming down from the mountains and about the upper end of the northern marsh. I cannot but think that there is a very prosperous future for this valley when capital and enterprise are found to make the necessary improvements for reclaiming the entire valley, which can be done by turning the stream and forming an irrigating ditch of it along the base of the mountains which constitute the western boundary of the valley. This would drain the swamps and furnish water for irrigating the reclaimed and the now arid and waste land between the swamps and the mountains.

The creek discharged when we were there in the dry season, in the middle of August, about 26 cubic feet of water per second, an ample sufficiency for every purpose. It rises in the mountains to the west, is full of the finest trout, and about its sources thousands of cattle find abundant summer range. Timber is plenty and within easy distance, and a saw-mill is in operation on the divide between this valley and Goose

Lake. Any one visiting this valley in a few years will, I believe, find it inhabited by many hundreds of people.

Leaving Chewaucan we proceeded to the north over a low barren divide into Summer Lake Valley, and kept on up the western side of the valley to Foster's ranch. This lake is of bitter alkaline water, entirely unfit for use except as a goose and duck pond. It is, I believe, strongly impregnated with borax, but am unable to say, as the water collected has not been analyzed. Most of the fertile patches along the lake are taken up and under cultivation. I am informed that the climate in this valley is much milder in winter than it is in any of the neighboring valleys, and can well understand why it should be so, for all the west shore of the lake, which is the only part inhabited, is shut in on three sides by the almost perpendicular cliffs of the Rim-rock Mountains, and consequently none, or at least very few, of the chilling winds of winter can reach it, while the lake on the east acts as a great heat reservoir.

As it continued uninterruptedly hazy, I gave up all attempts to carry any triangulation across to the Cascades, and, leaving Foster's, struck out for Klamath by crossing the Rim-rocks by the old Frémont Pass, and moving westward through the timber until the Sykan Marsh was reached. This, at the time we visited it, appeared a level meadow about fifteen miles long and ten miles broad, covered with splendid grass. A fine stream flows through the valley, with its banks bordered with tall willows and its waters enriched with great numbers of large brook-trout, of which several were caught, weighing from four to six pounds each. I was subsequently informed that the whole place is flooded in the spring and remains covered with water until June. The water has for its outlet the north fork of the Sprague River, and in the years past has so dammed up the outlet at the southern end of the valley by alluvial accumulations that at high-water in the spring the overflow is caused. The remedy is easy and unquestionable, by which the whole place may be reclaimed. It is the same action that has taken place in Goose Lake, whereby its outlet into Pitt River has been destroyed. This valley lies partly in the Klamath Indian Reservation, but the Indians seem to make no use of it at present.

Leaving, now, the southern end of this pretty valley, we proceeded to the southwestward, in the direction of Fort Klamath. Our way lay through the unbroken forests of pine, tamarack, cedar, and spruce; the soil of volcanic sand and ashes so light that at each step our mules sank into it above the fetlock joints. Every now and then a tract would be encountered which had been swept over by fire and hurricane, covering the ground with a network of charred and dead trunks, making progress doubly difficult and tedious. No grass and no water exists in these sterile wastes except little widely scattered patches and springs, and it was with great joy, after being for several days in these woods, that from the summit of a divide we came in sight of the Cascades, and knew that for the present our weary plodding through the deep and untrodden sand was nearly over.

Soon we came to the old Oregon Central Military Road, and continued on down it until we came to the Sprague River, thence down this noble river and across its tributary, the Williamson River, to Fort Klamath. Both the Sprague and Williamson Rivers have considerable bottom lands, which are now going to waste, for the Indians feed but few ponies on them and cultivate but an infinitesimal portion of the soil. Flowing over pebbly, rocky, and sandy bottoms, and with banks bordered by great pine barrens or beaver-inhabited cottonwood bottoms, green meadow lawns or willow clumps, the streams of this vicinity are the most beautiful in the world. Nothing could be more pure and clear than the waters of the Sprague and Williamson Rivers, and Fort, Wood, Annie, and the other creeks about Fort Klamath. All the streams are stocked with fish, nowhere else to be found in such abundance and quality. Trout of from three to fifteen pounds and sometimes larger are taken in these streams.

At Fort Klamath the outfit was divided, and Lieutenant Wheeler and his party set out northward along the base of the Cascade Mountains to the Columbia River, while I with five men went south to Mount Pitt, thence north to the Columbia, occupying as I went the high peaks of the Cascades. Going around by Spring Creek, Pelican Bay, the Dead Indian Road, and Rancheria Trail, we camped at Four Mile Lake, and the next day started to make the ascent of the peak, intending, if possible, to go up it by the long ridge which juts to the south.

After spending most of the day in picking our way through the labyrinth of fallen timber and beds of rock, we were completely stopped by great lakes of lava bowlders across which we could not go with our animals. We returned to camp, and after one more day spent in vainly endeavoring to penetrate the maze, on the third day we succeeded in climbing the peak, taking our animals to within about 500 feet of the top, where we camped among rocks so thick that we could not find a place to attain a comfortable position.

The next day we occupied the peak, and took such observations as the smoky nature of the atmosphere would allow.

Mount Pitt, or Wal-um-sen-yein (Rogue River Mountain), as the Indians call it, from the fact that it is the highest summit about the headwaters of Rogue River and its tributaries, is the most southern peak of the Cascades and a very beautifully shaped cone-like structure of volcanic rock. Wherever the slopes are not too great and it is a little sheltered, the mountain is covered about the summit with great and thick masses of snow. The ascent is extremely difficult and perilous, owing to the great rock slides which it is necessary to cross and sometimes to climb. From the summit the view is very grand and extensive. To the north the snowy range of the Cascades, sharp and jagged, extends until lost in the distance. It is flanked on both the east and west by numerous outlying spurs and foot-hill ranges. To the south the various mountain ranges of Northern California are seen in wild confusion; while towering high above all, Mount Shasta shows itself clear and white. To the west we overlook the fertile valleys of the Rogue River headwater streams, with their intervening mountains and thriving towns, while to the east the main features of the landscape are the Klamath lakes and marshes and hills of no great height. Woods are all around us as far as the eye can reach, covering every hill, bordering every lake and meadow—woods of yellow, black, and sugar pine, of tamarack, spruce, and fir, and impenetrable jungles of brush. Spread around us are many pretty mountain glacier lakes and meadows.

Leaving Mount Pitt, we retraced our steps to Klamath, and from thence started into the wilderness to the north, our first objective point being Mount Scott, the next high peak of the range. Our method of proceeding was to make as accurate as possible a time meander from one camp to another, and from camps to peaks and return; to make topographical stations on mountains and hills whenever practicable; to take sextant time and latitude observations at each camp, to make cistern and aneroid observations for altitudes at short intervals, and to connect our work by triangulation through to the Columbia River as well as the limited time at our disposal admitted. This latter part of the work was rendered impossible by the smoke and haze and the necessity for haste which my orders demanded.

The soil over which we traveled is composed of volcanic sand and ashes interspersed with basaltic bowlders, and with here and there an exposure of trap-dyke. Lumps of ashy conglomerate without grit abound, which can be worked into any shape and furnish an excellent powder for cleaning purposes.

We were continually in the forests of pine, except when we crossed the western arm of the Great Klamath marsh or traversed some little glacier meadow or tract of fallen timber overthrown by fire and wind. It is extremely hard traveling through this country, the soil being so light and loose that our mules sank fetlock deep at each step.

Mount Scott has the same general features that characterize most of the Cascades. It is of volcanic origin, and is covered on the eastern side with the ashes and light *débris* which have been carried over from the west and form a comparatively easy slope to the summit. On the west the bluffs are almost perpendicular walls of igneous rock, ragged and torn, among which nestle great masses of snow sheltered from the summer suns, and forming reservoirs of water which irrigate beautiful patches of green in the lowlands at their feet. To the southwest, following down these walls, we come at last to one of the most remarkable and interesting features of nature's handiwork that is to be found. In the calm stillness of an exquisite summer's day, lying there in the dense and lonely wilderness, we saw Mystic Lake, a great elliptical shaped basin of water about eight miles long by five wide, with walls of unbroken cliffs from 1,000 to 2,000 feet in height crowned with evergreens and pines. A little conical island near the center, with scattered trees upon it, is the only occupant of this weird lake. There is probably a subterraneous outlet of the lake in Sand Creek, which flows to the east and is absorbed in the waters of the Great Klamath marsh system. Many other lakes are to be seen in the neighboring regions, and interesting bits of scenery hidden away in the woods and hills.

Leaving Mount Scott, we proceeded northward, skirting along the eastern base of the mountains, passing on our way Mount Thielson, its summit peak in the shape of a cow-horn, and reaching, on the 14th of September, Diamond Peak, another of the typical high mountains of the Cascades. I ascended this peak and remained on its summit several days, but was precluded by the smoke and storms from making any good station.

In traveling from Mount Scott to Diamond Peak, we passed the divide which separates the waters of the Klamath system from those of the Deschutes and Columbia. The Deschutes drains all the eastern watershed of the Cascades from the latitude 43° 10′ to the Columbia, and by means of the Crooked River a large portion of the great interior basin of Central Oregon.

Odell Lake lies to the east of Diamond Peak and is the cradle of the West Fork of the Deschutes, being supplied by the melting of the great snow fields and glaciers about the eastern portion of the Diamond Peak cluster. It is a very wild, romantically-beautiful sheet of water, in size about five miles by four. There is no grass on its borders and the fallen timber and dense thickets of brush and tamaracks, and the miry bogs, made it impossible to reach the shore with our animals, and we were obliged to retrace our steps for some distance and camp on the supply stream of the lake, where our mules fared very badly, as, indeed, they had done most of the time that we were in this timber-covered country.

With infinite labor we progressed slowly on to the northeast; all we could do was to make about 5 or 6 miles per day, so dense were the forests and thickets, so soft the soil, so steep the hills, and such intricate masses and tracts of fallen timber blockaded our way. Climbing one day around the brow of a hill, we came in sight of another lake, cliff and tree environed, and with bottom lands and meadows of great extent, with what appeared to be mud-flats near the water. This lake and valley were about 12 by 6 miles in size, and took us completely by surprise, as they were evidently in the course of our West Fork and were not represented on any map. Reaching it we found at its southern end many acres of rich grass and bunches of tall willows. Following around the west shore to the northern end, we ascertained that there was no visible outlet. We saw the water-marks 20 feet above us on the lava-bluffs of the northern and northeastern shores, and camping beside these in the night we heard strange rumblings in the vast pile.

We found the next day that these lava beds formed an impassable barrier extending unbroken for about 4 miles to the north, and at their end we were again surprised to find, foaming out from underneath the giant bowlders the clear, cold river that we had seen lose itself in the lake 15 miles and more to the south. All was now plain to us. The masses of lava had been deposited in their present position by some tremendous convulsion of nature, forming a dam to the waters and thus making the lake and green grassy valley where before there was none. The noises of the night were caused by the water forcing itself through the interstices of the rocks and wearing them and causing them to tumble upon one another. The water-mark 20 feet above us shows where the waters rise in the spring, when the mountain torrents are swollen. This explains also why we found the valley unsettled, as it is overflowed the greater part of the spring and early summer. It cannot be many hundred years since the convulsion took place which resulted in the formation of this singular lake and valley, called Davis Lake by the few people who know of its existence.

Following on down the river, through the great forests of pine, now and then cutting across a bend, and often crossing tributary streams which bring the snow waters from the Cascades, seeing little land of any value for agricultural or grazing purposes, seeing deer in great numbers, and signs of other large game, we came to the Spring River, another specimen of nature's grand way of doing things. The source is a spring covering acres of ground and sending down to the Deschutes its waters in a stream 200 feet wide and 2 to 4 feet deep. The Three Sisters and their mountain neighbors must furnish the water which pursues its hidden way and rises at this great spring.

On the 22d of September we reached Farewell Bend, at which point there is a ford across the Deschutes. The river here is about 400 feet wide, running very swiftly over a rocky bottom, with a nearly uniform depth of about 2 feet. There are some very pretty meadow bottoms along this portion of the river. This has been a crossing-place for many years, and receives its name from the fact that the emigrants going north, east, or west in the olden anti-bridge times here bade farewell to the river.

From here we marched 27 miles to Crooked River, going by the old emigrant road. Our way lay all day along a rocky sage-brush desert, with junipers scattered more or less closely all over it. It was a great relief to emerge from the woods in which we had been traveling almost continuously for over a month, where our vision had been so contracted, out into the open country where the broad plains were spread out before us as far as the eye could reach. This plain across which we traveled presents the most unmistakable evidence of having been covered with a flow of molten lava from the mountains to the west of us. It is easy to distinguish the wave fronts where the fiery mass was arrested in its course by the hardening of its elements, and which enables us to imagine these hundreds of square miles as once a seething, struggling, turbid lake of fire.

At Crooked River I found Lieutenant Wheeler and his party, and separated again from him to rejoin the party at Warm Springs Agency.

In going from Crooked River to the Warm Springs Agency I did not follow the road, but struck across the country, intending to camp on Willow Creek. It does not do in this western country to expect too much, even to expect to find water in a creek, as to our discomfort we discovered on reaching Willow Creek that evening. We made a dry camp among the junipers, and consoled ourselves with a great fire. The next day we reached and crossed the Deschutes, after descending into its cañon fully 1,000 feet below the plain we had been traversing. Over this plain the bunch grass grows in great luxuriance, but there is very little stock upon it, owing to the scarcity of water. While encamped on Crooked River a storm in the mountains covered all the peaks with snow and cleared the atmosphere, and on our way to the agency we were greeted with a prospect the grandeur and beauty of which it would be hard to surpass. The great heights of Jefferson, the Three Sisters, Diamond Peak, and all the lesser mountains of the range, loomed up in their new and fresh robes of snow, pure white against the clear, blue sky, with their skirts of woodland showing folds and creases where sunny hill-slopes and shady cañons branched from the parent mass.

The exquisite beauty of this day's march will, I hope, never be obliterated from my memory.

The grand cañon of the Deschutes in this vicinity is about 1,000 feet deep, with walls almost perpendicular and impassable except at points quite remote from one another. All the country seems to be metamorphic in its upper strata and lacustrine or marine in the lower. To the west the country is considerably broken up into cañons and ravines, made by the streams coming down from the mountains. The Warm Spring Indian Agency is situated on one of these streams about a mile from the Deschutes.

Leaving the agency with an old Indian chief, Clem-tusch-na, as guide, I started for Mount Jefferson, which has never been ascended. The mountain was enveloped in clouds, and after experiencing a driving rain for two days, we retraced our steps, as we judged that it would be impossible to make the ascent over the loose snow which had fallen during the past few days upon the mountain. Indians out hunting came in with the information that the snow was 2½ feet deep at the base, which convinced me that it was too late to make the ascent of either Mount Jefferson or Mount Hood, as I had intended doing.

Leaving again the agency, we moved to the north over the rolling, cut-away mesa country, and at about 8 miles distance came to the Warm Spring River, upon which we found quite an encampment of Indians, lolling about in listless idleness in the pleasant, warm weather. At the Warm Springs, about an eighth of a mile from the village, there were a number of Indian women disporting themselves in the basin which had been hollowed out for the purposes of the bath. The cañon of this creek is very deep, and over the hills and down to this place, which is the winter home of the Warm-Springs, many trails lead. About the cañon and on the hills many horses were grazing, and some few cattle, but the latter were in nearly every case poor and scrawny, although the feed was excellent, and this I attributed to the lack of salt. Hence we kept on our way over a country which commenced to give evidences by its vegetation that we were approaching more nearly to the sea-level and a more moist condition of the atmosphere, until we came to Oak Grove, a stage station and store, where the road debouches from the Mutton Mountains into the plains or valley called Oak Grove. Here I found the rest of the party, and sending Mr. Karl to survey the new road which leaves this valley and joins the Barlow road and crosses the mountains to the south of Mount Hood, I, with the main party, kept on across the plains of Oak Grove to Tygh Valley. This plain has several valley settlements in it, the most notable being the Womack settlement and that around Wappinitia, the main post-office of the valley. It is quite well covered with grass, and is being rapidly settled up, as it has been pretty thoroughly demonstrated that crops of cereals, potatoes, and fruits can be raised in this country without irrigation, and water enough for domestic purposes can be obtained by sinking wells.

From this plain we descended into Tygh Valley, which is at the bottom of the old cut made by the White and Tygh Rivers. It lies about 500 feet below the Oak Grove plain, and is a level, pretty valley, some ten miles long, and averaging about one to one and a half miles wide. The White River, with its whitish muddy waters, breaks out of its rocky, clear-cut cañon into the valley, and is joined by the Tygh Creek, the two forming a considerable stream, which at the east end of the valley flows into the Deschutes. Before, however, reaching the Deschutes it runs over a precipice, forming a very pretty waterfall, where Mr. Sherar, the most enterprising business man of the region, has built and is running a fine flour mill. From Tygh Valley to The Dalles the distance by the road is about thirty miles, and leads over a succession of hills and ridges, gradually diminishing in altitude until the Columbia is reached. In this region there are several streams of water, but as they run in deep cuts, the water is only available for irrigation on the lands at the bottom of these cuts, and it has until within a year or so been considered that all the land of these rolling hills was useless for agricultural purposes. But within a short time different ideas have prevailed, and now farmers are rapidly settling up the country and raising good crops. And it is claimed that better crops of grain can be raised on the hills than in the bottoms

Our first view of the Columbia was very disappointing, for looking down upon it from the hills above The Dalles it appears a very small stream, winding its way through the rents of a great bed of basaltic rock, while to the north were the great dry, barren-looking Klikatat Hills; and in the nearer foreground the rocky flats, partially covered with dunes and heaps of drifting sand, marked a very picture of desolation. Below and at The Dalles, however, the river widens out nobly, and its waters are breasted by the steamers of the Oregon Steam Navigation Company, which has also built a railroad around the unnavigable portion of the river above The Dalles, from the latter place to Celilo, whence others of their boats carry passengers on up the river.

The Dalles is the most important town of Oregon east of the Cascades, the county seat of Wasco County, and is situated at the head of navigation of that portion of the river between the Cascades of the Columbia and the narrows above the town. This is the grand *entrepôt* for all the great interior basin of Oregon and for a large part of Washington Territory, and it is safe to assume that there are more than 40,000 square miles whose white inhabitants draw their supplies almost exclusively from The Dalles. This assumes a large forwarding business, continually increasing, which is entirely done by wagons. The town is well supplied with water from Mill Creek. The population is about 1,500 souls.*

At The Dalles I found an astronomical monument which had been erected and its position determined by Mr. Clark, and in obedience to instructions I set about the work of finding and measuring a base line and developing it. I selected a base extending from just west of the burying-ground, near the old mission, to a point in the race-course, about one and three-fourths miles in length. This was carefully cleared away and measured, but as we had no standard rods to compare our tape, it had to be sent to Washington to be compared there as we used it. There being no good natural points in the vicinity, I developed the base to the Klikatat Hills, previously building monuments upon them about twelve miles apart on the two highest. These hills lie just north of the Columbia River, with a narrow belt of bottom land intervening. They are covered with bunch-grass, and some fine springs exist, which, however, do not furnish water enough for the great number of cattle and sheep that could find sustenance thereon. Beyond these hills lies Klikatat Valley, through which runs Klikatat River, discharging its water into the Columbia several miles below The Dalles. This is a very fine valley of many miles in extent, and studded over with houses and claim shanties. Away to the north, at the foot of the wooded hills, lies Golden Dale, the valley town. All the supplies of the valley are procured at The Dalles, and all products find a market there. The rivers and the hills form a great drawback to the valley, as to get to The Dalles it is necessary to cross the Columbia on a ferry-boat, to which the legislatures of Oregon and Washington Territory have given the right to charge exorbitant prices for services performed, and also to cross these hills by a winding road which ascends some 3,000 feet in about ten miles, and descends in about the same distance.

While engaged on the base measurement, one party under Mr. Karl was kept at work doing topography about the vicinity of Mount Hood, both south and north of the peak. On the 27th of October we had finished measuring the base. The azimuth taken here is not to be relied on, as the instrument used was old and unreliable, and unprovided with an axis-level.

On the 29th, Mr. Kahler, Mr. Goad, Collins, and Condit started on their return to Bidwell, by the Cañon City road to old Camp Watson, across to the Harney road, and via Warner Valley. An account of the trip is appended. On the 30th Mr. Henshaw left us to return to Washington, and we left The Dalles and marched along the river-road to Miller's Bridge, which crosses the Deschutes near its mouth. The town of Celilo lies just below the mouth of the Deschutes, on the Columbia, and is the eastern terminus of the railroad from The Dalles and the landing place for the Oregon Steam Navigation Company's steamers which ply up the river. From the bridge, which is a strong, well-kept structure, we proceeded up the Columbia by the wagon-road until opposite Columbus, where there is a ferry. Here we left the road and went over the trail along the bluffs. This is an excellent type of a good Indian trail, very picturesque and well selected. We camped at Grant's Landing, and made a station on the highest peak of the Klikatat Hills, opposite Celilo. The hills are covered with grass, but water is lacking.

From Celilo we turned southward, traversing the section of country lying between the Deschutes and the John Day Rivers. From the great bend of the John Day at Bridge Creek the river runs nearly due north, as also does the Deschutes, the two rivers forming the two sides of a parallelogram about seventy miles long and thirty miles wide. The cañons of both rivers are very deep and steep, and the land rises into roundish hills with intervening ravines and lowlands. The soil of nearly all this section is excellent, and is covered with a luxuriant growth of bunch-grass. Unfortunately, there is a great lack of water, which will hinder its speedy settlement very much. These hills are bare of timber, and and are called haystacks from their shape and their covering of grass. At Grass Valley, where there is a little stream, a settlement is forming, and water is very easily obtained by digging a short distance. We crossed the Deschutes again by Sherar's Bridge, at the lower end of Tygh Valley, being obliged to go by way of the Mutton Mountains and the Warm Springs Agency for supplies. Some idea of the difficulty of crossing the Deschutes and the depth of its cañon is shown by the fact that we descended constantly, by a well-graded road, through side cañyons for a distance of six miles before reaching the bridge. Here Mr. Sherar has constructed a very ingenious little fish-trap for taking salmon, which he preserves. Near the bridge there are some little falls, and a small rocky island just above the falls separates the channels forming the falls and a little side chute much easier of ascent for the fish than the falls. At the head of this chute he has made a trap which receives the fish and forces it to find egress through a flume which gently conducts it to the fish-house, from which it only emerges after being killed and salted.

After working several days among the Mutton Mountains, we returned to the agency and laid in a supply of provisions for our trip to Camp Bidwell. We all received much kindness at the hands of Captain Smith, the Indian agent, and his assistants, and I wish to bear testimony to his great success in the management of the Indians and their advancement in the arts and customs of civilization. From a state of savage degradation he has in a few years taught them to build and live in houses, to cultivate the ground with improved agricultural instruments, to provide in proper season for future wants, to wear ordinary clothing, to respect age and womanhood, to attend the religious exercises, to learn trades, and to dispose of their ponies and purchase cattle. A good school is in operation. Some of the children show a very considerable aptitude for learning. These remarks apply mostly to the Wasco tribe, on whose particular domain the agency is situated. The Warm Springs are still in much more of a state of nature, living in wigwams of skins or cotton, and subsisting chiefly by hunting and fishing.

Leaving the agency, we crossed again the Deschutes by the Indian Ferry and bade farewell to this beautiful river. Traveling on by the settlement at Willow Creek we crossed by the road to the mouth of Grizzly Butte to Prineville, a thriving town situated at the junction of Ochoco and Crooked Rivers, and in the midst of a stock-raising and agricultural district. Several good stores, mills, shops, &c., are here, and it is growing rapidly. After remaining here one day we started in a drizzling rain to cross the desert to Silver Lake. Our first day's march of 25 miles brought us to Green's Ranch, where we had plenty of good water, wood, and grass. I could not resist the temptation to remain over one day and hunt in this vicinity, where the mule deer is so plenty. We were rewarded by having seven deer in camp at night. This desert country, especially the mountains and hills about Bear Creek and the Bear Creek Buttes, is the great winter range for the deer of the Cascades. Leaving Green's our next watering place was Laughton's, to reach which we traveled two days, making a dry camp at night. The water here is very scant and poor, and has to be dipped up with a basin from a deep hole in the ground.

Our next camp was on Christmas Lake, at Button's Ranch, and from here we marched to Silver Lake, and the desert was crossed. We passed at Button's within a short distance, about eleven miles, of the sandy desert where the petrified animal remains have been found, and at the ranch we secured some fine specimens. The desert that we crossed is in some places rocky and in others has a scanty growth of grass and sagebrush and some junipers on the hills; taken as a whole, it is about as worthless a country as it is possible to find. It extends from the Cascades to the Rocky Mountains, with a width of from 100 to 200 miles. This vast area is crossed by several rivers, has some streams, sinks, and springs, but on the whole is a very desolate country. We were glad to get to Silver Lake and among the settlements again. This lake is a fine fresh-water sink, fed by Bear, Bridge, and Silver Creeks, bringing down the water from the mountains to the west. Around the lake there are a goodly number of ranches, especially about the west and northwest in the bottom lands traversed by the above-mentioned creeks. The road for the south leaves Silver Lake, and passing over a rough rocky dividing range of hills descends into Summer Lake Valley, and continuing on down the west shore of the lake it crosses over into Chewaucan, and down this valley, and crosses the dividing ridge into Goose Lake Valley. Thus we have a continuous string of valleys with low divides extending about 125 miles nearly north and south, traversed by a good road. On the heavily timbered divide between Chewaucan and Goose Lake there is a good saw-mill which furnishes the people of the valleys with lumber.

On Thanksgiving day, November 28, we reached Lakeview, the county seat of Lake County, Oregon, and a thriving town. Hence we marched to Camp Bidwell, going by the new road being built by Mr. Ayers across the Warner Mountains. This is an excellent road, and will be the chief route across the mountains when fully completed.

We reached Camp Bidwell on the last day of November, about five o'clock, and within half an hour the side party under Mr. Kahler, which had been detached at The Dalles just one month before, came in also. This coincidence in time of arrival after traveling each about 400 miles and working along the route was a little remarkable.

Being under orders not to disband until the 15th of December, I sent Mr. Kahler with a party to do some work in the unfinished atlas-sheet east of Bidwell, which, however, they were unable to do, on account of a severe snow-storm, and they wisely returned to the post. After the work of the disbanding camp was done, I sent Messrs. Kahler, Goad, and Pitcher in an ambulance, kindly furnished by the quartermaster of the post, to Reno, meandering the road thereto. This finished the field season of 1878, so far as work in the field was concerned.

The party of four men, consisting of Mr. C. P. Kahler, Mr. T. W. Goad, Frank Collins, and Jack Condit, which left The Dalles October 29, moved first to the southeast, meandering the road and putting in the topography of the country between The Dalles and Sherar's Bridge across the Deschutes. Thence the party crossed the river and worked up the country lying between the John Day and the Deschutes Rivers, in the southeastern part of atlas-sheet 20 A. This section is to a great extent covered with rich bunch-grass; in some parts, however, it is rocky and covered with small bowlders. The country is cut up with cañons debouching into the Deschutes or John Day and many branch ravines and cañons. Water in small quantities is found in many of these cañons, and also considerable timber—cottonwood and willow. After spending some time about this country, the party struck out for Camp Bidwell, traveling at first by the Cañon City road. About Currant Creek and Cherry Creek the country is described as being very rough and piled up into small hills with massive jagged rocks cropping out in every direction, assuming fantastical shapes. It was down among these hills and rocks that the settlers of the country round about, during the Indian excitement of the summer, brought their flocks of sheep and herds of cattle and horses.

Leaving the John Day River at the mouth of Bridge Creek, the party proceeded along the road up this creek, and over the mountain road, towards Old Camp Watson. Mr. Kahler says of this section: "All the section that we have traveled through to-day, and some distance to the eastward, presents a rich field for the geologist—every variety of rock, quartz, sandstone, granite, limestone, conglomerate, &c. Numbers of fossil remains of animals of different kinds, also the impression of palm leaves and other tropical plants, have been found in the strata on which the rim-rock rests. The country presents the same rugged, broken appearance as that we passed through yesterday. With the exception of where we are camped this evening, the country has been pretty well cleared of grass by the sheep and cattle. The country is fast filling up with settlers." Over the mountains to the southward, through a country alternately covered with grass and destitute of all vegetation, the party traveled and came to Beaver Creek, a tributary of the Crooked River. From Beaver Creek across to Buck Creek the route lay through Long Hollow, well watered and with great quantities of grass. From Buck Creek, across a timbered ridge, the party passed to Silver Creek, and camped at Old Camp Curry.

Mr. Kahler says: "Making an early start from Camp Curry, our course was to the southeast down Silver Creek for about 25 miles. All the country from Camp Curry shows strong evidences of the devastation committeed by the Indian raiders. With the exception of the ranch near which we are camped to-night, all are deserted. About all of the ranches are to be seen the carcasses of the horses and cattle killed by the Indians. From Camp Curry our route lay over a flat alkali country, covered with sage-brush and greasewood and in season with tolerable grass, to a point where Silver Creek passes through a rocky gorge, about 13 miles from Camp Curry. It was at this point that Captain Bernard had a fight with the Indians, and near are the stone breastworks thrown up by his men."

Thence the party marched until the Harney road was reached, and on this road across the desert to Mule Springs, and thence to Warner Valley, and by the main traveled road to Bidwell, which point it reached November 30. The party experienced many hardships, as it was very cold and stormy most of the time, rain and snow falling, and the roads being either very muddy or frozen and slippery.

The results of the field-work of this section of the survey have been to give three and partially four reconnaissance lines across Oregon from California and Nevada to the Columbia River. These lines were all carefully meandered, the country as far as possible in the vicinity examined and sketched, profiles run with cistern and aneroid barometers, and checks made at frequent intervals by sextant latitude observations.

Particular attention was paid to gaining such information as will be useful in a more thorough and elaborate survey of the area; peaks suitable for triangulation and topographical purposes were located as closely as possible; the general characteristics of the country were noted with reference to the supplies it can be made to furnish, and also with reference to the accessible and practicable routes of travel.

Besides these lines, a base line was measured and developed and connected with the astronomical monument at The Dalles, and the topography of the quarter atlas-sheet 20 A was nearly completed, all being done except the work in the immediate vicinity of Mount Hood, which could not be accomplished on account of the lateness of the season.

The following is a numerical list of the principal observations made during the season, number of miles traveled, &c:

| | |
|---|---|
| Number of sextant latitude stations occupied | 18 |
| Number of bases measured | 1 |
| Number of azimuths measured | 1 |
| Number of triangles about bases measured | 4 |
| Number of main triangulation stations | 11 |
| Number of secondary triangulation stations | 1 |
| Number of meander stations occupied | 2,195 |
| Number of variations of needle taken | 57 |
| Number of miles meandered | 2,673 |
| Number of miles traversed and not meandered | 608 |
| Number of monuments built | 18 |

| | |
|---|---|
| Number of camps made during season | 128 |
| Number of cistern-barometer stations | 169 |
| Number of aneroid stations | 1,570 |
| Highest altitude, approximately (feet) | 9,500 |
| Lowest altitude, approximately (feet) | 310 |
| Number of thermal springs | 3 |
| Number sets sextant time observations | 22 |
| Number sets hourly barometric observations | 1 |
| Number of pointings at main and secondary triangulation stations | 803 |
| Number of rivers and creeks gauged | 1 |
| Number of rock specimens collected | 2 |
| Number of specimens of mineral waters collected | 1 |
| Number of zoological specimens (about) | 1,000 |

I have the honor to be, very respectfully, your obedient servant,

THOMAS W. SYMONS,
*Lieutenant of Engineers.*

Capt. GEORGE M. WHEELER,
*Corps of Engineers, in charge.*

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## APPENDIX C.

### REPORT OF LIEUTENANT EUGENE GRIFFIN, CORPS OF ENGINEERS, IN CHARGE OF PARTY NO. 2, COLORADO SECTION, SEASON OF 1878.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
*Washington, D. C., March* 26, 1879.

SIR: I have the honor to submit the following report of the operations of party No. 2, Colorado section, of the surveys west of the 100th meridian during the field season of 1878.

On the 5th of July, in accordance with your orders, I left Washington for Fort Union, New Mexico, the rendezvous camp of party No. 2, Colorado section. I was delayed at Fort Garland, Colo., assisting Lieutenant Birnie in fitting out his party (party No. 1, Colorado section), and on other duty, reaching Fort Union on the 21st. On the 4th of August the party was completed and ready to take the field, organized as follows:

Lieutenant Griffin, executive officer and field astronomer; Mr. F. O. Maxson, topographer; Mr. W. G. Walbridge, assistant topographer; Mr. Mark B. Kerr, meteorologist; Mr. W. A. Phillips, jr., odometer recorder; three packers, and one cook. The party was provided with the usual allowance of instruments, the necessary camping outfit, eight riding-mules, twelve pack-mules, and one horse.

My instructions were to proceed southward from Fort Union to Fort Stanton, completing, on the way, the detailed meander work in atlas-sheets 78 A, 78 C, and 77 D; after refitting at the latter post to carry on the detailed topographical survey of atlas-sheets 84 D, and that part of 84 C lying eastward of the Rio Grande.

On the 5th day of August the party left Fort Union, and topographical work was commenced on the following morning, the party filling in those portions of sheets 78 A and 78 C where additional details were required. At Pozos del Pino, or Alkali Holes, on the 14th, the party was divided, Mr. Maxson, with Mr. Kerr and one packer, passing to the east of the Gallinas Mountains, and the remainder of the party to the west, thus enabling us to complete, at once, all work requisite for the final plot of atlas-sheet 77 D. On the 17th Mr. Maxson reached Stanton with his party, and I arrived on the 18th.

This area has been traversed, in previous years, by parties of the survey, and complete descriptions of the country given in their reports. The narrow belts which we worked up presented no marked features, and differed in no respects from their surroundings; they do not, therefore, require further remark. Sheets 84 D and 84 C, the survey of which constituted our main season's work, had never been entered previously by parties of the survey. To give an intelligent idea of our movements necessitates a brief description of the country in which we operated.

Sheets 84 D and 84 C are included between the parallels of 33° 10′ on the north and 32° 20′ on the south, and longitudes 105° 30′ on the east and 106° 15′ on the west. The area designated for the party to occupy, however, was limited by the Rio Grande on the west, which included only about two-ninths of sheet 84 C. This designated area is approximately 5,618 square miles.

Bordering the Rio Grande lies the Caballo range of mountains, trending nearly north and south. Rising rugged and precipitous in the north, they decrease in elevation toward the south, finally dividing into a double range, and sinking gradually to the plain in latitude 32° 40′, where the river bends to the east. But little water is found in these mountains; indeed, nearly all this portion of the Territory, except a strip of varying width bordering the river, is dry, and, were one dependent on natural water supplies, would be well nigh impassable.

About thirty-three miles to the east are the San Andreas Mountains. These also lie meridianally, and are more elevated and broken, more barren and dry than the Caballo Range. They are a southern prolongation of the Oscuro Mountains. In latitude 32° 25′ they break down nearly to the plain, forming the San Augustin Pass. South of this they rise even higher than before, and are there called the Organ Mountains. The towering, conical, and slender pinnacles rising in profusion, but with regularity, resemble the pipes of an immense organ, and suggested the name, which is certainly appropriate. Again, they are broken by the Soledad Pass, and south of this they are known as the Soledad Mountains, and still further down as the El Paso or Franklin Mountains. Near the town of Franklin, Tex., they come to an abrupt termination. The Rio Grande, bending eastward, cuts through the range, forming here the boundary between the United States and Mexico.

The Jornada del Muerto (Journey of Death) lies between the Caballo and San Andreas Mountains. This is a dreary level waste, stretching from the Fra Cristobal Range on the north for some ninety miles to the south. It is covered with fine gramma grass, but the scarcity of water renders it valueless for grazing purposes. The Ojo del Muerto (Spring of the Dead), near the north, Toussaint's Ranch, Martin's Well, and a stage station at the Point of Rocks are the only places where water is to be found.

East of the San Andreas Mountains is another plain, a sandy desert, stretching for some 43 miles to the east and terminated there by the Sacramento, Guadalupe, and Hueco Mountains. This was over the bed of an ancient ocean, but the waters have long ago receded, leaving only salt lakes and marshes dotting the plain and surrounded by quicksands. In brief, the area to be surveyed consisted of three parallel ranges of mountains, separated by two extensive plains or deserts.

It was considered advisable to work up the San Andreas Range at once, during the rainy season, as later on it would be more difficult if not impossible, owing to the scarcity of water. The necessary repairs to the outfit being completed, on Monday, the 26th day of August, the party left Fort Stanton. For three days we were accompanied by Lieutenant Wright, Ninth Cavalry, and twenty Navajo Indian scouts, who being skillful hunters, kept us supplied with game. On the 27th we reached the Mal Pais, an immense lava bed, which had been surveyed the previous year by Lieutenant Morrison, Sixth Cavalry. Crossing this by one of the only two practicable or possible routes, we proceeded down the western edge, and on the 30th entered the area of atlas-sheet 84 D, making camp at a water-hole fortunately filled by recent rains. Mr. Maxson, with one packer and ten days' rations, left us at the camp, to work down the range, carrying the meander well over to the western border and into the Jornada. This difficult and laborious operation was completed with his usual skill and success.

From the Mal Pais Spring, at the southern point of the lava-bed, a wagon-road runs south, along the eastern edge of the mountains, to the San Augustin Pass. The main party meandered this road, and obtained all the details, both of the plain and the mountains in the vicinity. The road followed was, at times, hardly passable; pools of water were seen, but investigation showed them to be salt, and the surrounding quicksands made them difficult of approach; a running stream of the clearest water was also salt, and on following the road to the edge of an immense salt-marsh we found ourselves plunged in a dangerous quicksand. With difficulty the pack-mules were extricated, and, abandoning the road for a time, we continued our journey on the higher ground near the mountains. No water was found at the end of the first day's march, and our camp was made on the sand, with but little if any grazing for the animals. On the following night we camped at the San Nicholas Spring, about two-thirds of a mile up a cañon in the mountains.

The clearness of the atmosphere at the high altitude we were in (about 4,200 feet), made objects distinctly visible at almost incredible distances. From this camp, looking across the almost level desert at our feet, we could see the Sacramento Mountains on the farther side. Their outline could be clearly traced; the mouths of the immense cañons which abound on their western borders were distinctly visible; the giant masses of rock forming the sides of the cañons, rising in some places to a vertical height of 2,000 feet, seemed so near that the mind refused to credit their extreme distance of 50 miles.

We remained at this camp for five days, obtaining the topography in the vicinity, and being detained by heavy thunder-storms. Mr. Maxson arrived on the 6th, and on the 9th the main camp was transferred to San Augustin. The Organ Mountains on the south, and the San Andreas Range on the north, bending westward at this point, form an immense rincon, open to the east and rising gradually to the San Augustin Pass. On the northern slope of the Organs are several springs, and here two dwellings have been erected, forming the town of San Augustin.

In 1866 Mr. W. F. Shedd made the first settlement here, and Shedd's ranch is widely known in this country, more so, perhaps, than the more recent appellation of San Augustin. It is only within the last few years that traveling, even in parties of considerable size, has been safe in this vicinity, on account of the Indians. The erection of military posts and the increased number of troops have confined the Indians more closely to their reservations, and the traveler is now comparatively safe. The grazing on the long, gentle slopes is excellent; though not luxurious, the grass seems to possess great nutritious properties, and supports a flock of some 10,000 sheep and several herds of cattle.

A good wagon-road leading over the pass crosses the Jornada del Muerto to Las Cruces and Mesilla—two towns on the Rio Grande. A branch from this, just across the pass, leads to the town of Doña Ana, a few miles north of Cruces. From the pass a road leads direct to Fort Selden, on the river. On the 11th the party crossed the pass, and, following the Selden road, while Mr. Maxson meandered that by way of Doña Ana, reached Fort Selden the same night.

Fort Selden had ceased to be a military post, but the Government property still there was guarded by a small detachment, under command of Lieutenant Cory, Fifteenth Infantry.

After resting the transportation two days at this post, we journeyed northward through the Jornada over a well-traveled stage-road, remained in camp one day at the Point of Rocks, while the topographers were working in the vicinity, and reached Aleman or Martin's Well on the 16th. Here, in the center of this vast sandy plain, is a well of pure water, having a depth of 160 feet.

On the 17th we camped at the abandoned post of Fort McRae. On the 19th we crossed the Caballo Mountains over the Palomas Pass, and made camp on the bank of the river. The pass is utterly impassable for wagons; in fact, it can hardly be called a pass, as the trail leads directly over the crest of the mountains, hardly lower at this point than at others. It was a delightful change from the barren plains on which we had been traveling to the rich, fruitful country in which we now found ourselves. Between the mountains and the river the soil is fertile and well cultivated, and the many trees afforded us a grateful shelter from the scorching sun. Watermelons, cantaleupes, fruits, and vegetables of all kinds, and chili, the national dish of the Mexicans, were plentiful and cheap. The ground is irrigated by acequias or ditches, which, starting from the river several miles above the town which they are intended to supply, follow a gentle slope, and distribute the water by side drains throughout the place. The acequias are municipal works, and the major-domo de las acequias, or superintendent, an important municipal functionary, is elected by the people. In cases of emergency, he is empowered to turn out the entire population to save the acequia, which is frequently the only water-supply of the village.

We had reached the northern limit of our work, and after remaining four days in this camp, to enable the topographers to complete their notes, we started down the river on the morning of the 24th. Our object now was to meander the river, and at the same time obtain the necessary data for an accurate plot of the mountains on our left. In following the course of the river, in many places we were obliged to travel on narrow trails literally cut into the face of the mountains, which, stretching out to the river, presented nearly vertical walls. These difficulties were finally overcome, and on the 27th the party reached Fort Selden without accident.

On the 29th we started southward on the stage-road, and passing through Doña Ana, camped in Las Cruces. Doña Ana is a true Mexican town, formerly very prosperous and the commercial center of the southern part of the Territory; now it has greatly diminished in population and its commercial importance is entirely gone. Abandoned and ruined dwellings line the plaza and mutely tell of its departed glory. Las Cruces and Mesilla are the successful rivals. The former is situated about nine miles farther down the river, and is one of the most important towns in the Territory, having a population of about fifteen hundred. Mesilla, a few miles farther south, on the western bank of the river, has a population of one thousand.

On the 1st of October we reached Fort Bliss, in Texas, 46 miles south of Cruces. The country through which we had traveled was a continuation of the Jornada del Muerto, and marked by the same characteristics. The road turns from the river bottom, after leaving Cruces, and in following it we lost the river until just as we approached Fort Bliss.

The troops were quartered in the little town of Franklin, occupying buildings rented by the government, no quarters having been erected or reservation designated for the post. We remained in camp here until the 15th. During this time we were treated with the greatest courtesy by all the officers at the post, who gave us every assistance in their power, and contributed in every possible way to the speedy and successful completion of our work. We received like courtesy and consideration from all officers with whom we came in contact.

Fort Bliss had been occupied as an astronomical station by Mr. Rock, of the survey, earlier in the season, and I had instructions to connect his monument with the main triangulation to the north, and also to connect with the initial monument of the Mexican Boundary Commission which located the Mexican boundary in 1855. For this purpose I at once commenced the measurement of a base line. A nearly level plain, about 5 miles to the east of Franklin, was selected, and after the direction of the line had been determined and the ground prepared, two measurements were made with a stackpole, 50-foot, compensated, steel tape. The first measurement was made by Messrs Maxson and Walbridge, and the second by Mr. Maxson and myself, resulting as follows:

| | |
|---|---|
| First measurement, 8049′.689+0′.632 (temp. correction) | 8050.321 |
| Second measurement, 8049′.789+0′.512 (temp. correction) | 8050.301 |
| Mean adopted | 8050.311 |
| Level correction | 0.030 |
| Reduction to sea-level | 1.321 |
| Length of base at sea-level | 8048.960 |

The temperature of the tape was read every thousand feet, and the difference of level obtained for the same distances, the character of the ground rendering any further refinement in the latter respect unnecessary. Eight triangulation stations were occupied, including the two ends of the base and two monuments of the Mexican Boundary Commission. One mountain-peak was occupied in Mexico. In this work Mr. Maxson was invaluable, and I cannot testify too highly my appreciation of his zeal and energy and thorough familiarity with his work. I am also indebted to him for many timely suggestions, which his knowledge of the country and long experience on the survey rendered doubly valuable.

On the morning of the 14th Messrs. Walbridge and Phillips, with one packer, started northward for San Augustin, following a good wagon-road which runs to the east of the Soledad and Organ Mountains. The last two triangulation points of the development were successfully occupied during the day, and on the 15th the main party followed, abandoning the road, however, and making camp at a little spring in the mountains. On the following day we climbed and occupied the North Franklin Peak, the remaining point of our system of triangles. In the descent, by an unfortunate accident, the triangulation instrument was ruined, falling some 400 feet down the side of the mountain. On the 17th we reached Shedd's ranch, after a weary march of 41 miles, and found the remainder of the party in camp there. Here we remained for six days, the topography of the Organ Mountains being obtained by short trips from this camp. On the 23d I visited the Stevenson Mine in these mountains, the only mine within the area we occupied that has been worked. On the 24th we left Shedd's ranch for the last time *en route* to Fort Stanton, following a well-traveled road. On the 25th we camped at the White Sands, on the Mal Pais plain. This is a peculiar formation; an area of about 46 square miles is covered to a mean depth of about 30 feet with gypsum. At a distance it has every appearance of an immense snow-bank, and even on close approach it is difficult to divest oneself of this impression. The sand is rather coarse; shrubs and bushes grow in it to some extent. It is said that this bank shows a continual growth, and there is abundant proof of its yearly increase in a horizontal direction. The road runs close to it, and the constant encroachments of the sand have in time converted what was formerly a straight road into an immense arc. This is probably due, however, to the drifting of the sand by the winds rather than to an actual increase in the total bulk. A spring bubbles up from under the sand-bank, and the water, though not palatable to man, is greedily consumed by the thirsty animals after their long and hot journey through the sands; it is strongly alkaline and mineral. On the following day we passed the Lost River; a considerable stream rushing up from the ground like an immense spring, flows on about ten yards, and sinks as mysteriously as it rises. The source and mouth of this mysterious river are unknown; at no other point in its course is it visible. That night we camped at the town of Tulerosa, and three days later arrived at Fort Stanton.

After resting two days at the post, we started, on the 1st of November, to complete our work in the Sacramento Mountains. On the 2d we camped at Elk Spring, 42 miles from Stanton. Our camp was in a beautiful cañon, with excellent grazing for the mules, and wood and water in plenty. With a few exceptions, we were equally fortunate during the next three weeks. These mountains are in reality an immense plateau, on their eastern slope cut by gentle cañons, with long and numerous branches running from the divide out towards to the Staked Plain. On the western slope the cañons are deep and rugged, with high, precipitous walls. They are heavily timbered, principally with pine, though scrub-oaks and quaking-aspens are quite numerous. They are well watered by several streams and by many springs. These springs are much more numerous on the eastern than on the western slope. Game is plentiful. Bear, deer, and turkeys, especially the latter, are numerous, and, judging from the tracks and cast-off antlers, many elk still range these mountains, though it was not our fortune to see one of these animals. The greater part of the mountains lie within the Apache Indian reservation, and this fact has kept settlers and prospectors almost entirely out of the country.

Work was prosecuted vigorously until the 22d, suspended only on the 8th and 9th by snow-storms. In these nineteen days we meandered 356 miles, and traveled altogether 626 miles. On the 21st and 22d we were without water, having left our water-kegs behind at Fort Stanton, and failing to find any springs, we turned back toward the Peñasco Creek, which we had left about a week before, and at noon on the 23d we reached it, with the mules in a very weak condition and the members of the party heartily tired of subsisting on bear's meat alone. At 5 a. m. on the 24th a violent snow-storm began, which continued all day. The next morning found the ground covered to a depth of 15 inches, and no signs of a cessation of the storm. At 7.30 a. m. we broke camp and started for Fort Stanton, a distance of 79 miles. At 4 p. m. the storm ceased, leaving a depth of over 2 feet, and we camped at a little spring. The mules were in a very bad condition. Lack of food, combined with the intense cold and difficult traveling through the snow, had weakened them all, and it was doubtful whether they could hold out. On the 26th we traveled 21 miles, and camped at Elk Spring. On the 27th 22 miles brought us to Dowlin's Mill, a government forage agency, and on the following day we easily made Fort Stanton. I found awaiting me instructions to disband the party on or about the 10th of December. Accordingly, the property was boxed and stored, and on the 7th the party disbanded, and the several members started for their homes.

The following is a summary of the work done:

| | |
|---|---|
| Main triangulation stations occupied | 9 |
| Secondary triangulation stations occupied | 8 |
| Three-point stations | 251 |
| Meander stations | 1,898 |
| Number of variations of needle determined | 30 |
| Cistern-barometer stations occupied | 98 |
| Aneroid-barometer stations occupied | 1,235 |
| Pointings made on triangulation stations | 2,249 |
| Miles meandered | 1,679.68 |
| Total miles traveled | 2,672.57 |
| Square miles surveyed | 4,656 |

There are no valuable mines in the area we occupied that have been discovered and worked, but this subject has never received the full investigation that it deserves. Argentiferous galena was found through the San Andreas and Organ Mountains, and there are indications of both silver and gold bearing rock in the Sacramento Mountains. The galena ore is not valuable, however, only averaging from $10 to $18 to the ton

The Stevenson mine, in the Organs, has been worked, but to little profit. The distance from the railroad and consequent great cost of transportation has induced the owners to stop work for the present. A lawsuit, now in progress, involving the title to the mine probably had its influence in this respect also. Most of the silver thus far taken out has been found in pockets in the limestone that constitutes the surface-rock. A shaft has been sunk, however, and a true lead reached in the solid granite. This lead trends northeast and southwest. From different assays, and the practical working thus far, the rock is found to average about $33 to the ton.

Wool is, perhaps, the most important product of the country. The immense plains and sheltered rincons in the mountains, together with the mild climate, make this country one well adapted to sheep-raising, and considerable wealth is invested in this branch of industry.

Cattle-raising is the principal occupation of many. Agriculture is but a secondary pursuit, as there are so few places where the soil is suitable.

Franklin, or El Paso, Tex., is the seat of the custom-house of the district of Paso del Norte. On the opposite bank of the Rio Grande is the old Mexican town of El Paso, having a population of about 5,000. The character of the commercial intercourse between the two countries, at least in this district, is shown by the following table, kindly furnished me by Mr. Slade, the collector of this district, to whom I am indebted for many other acts of courtesy.

DISTRICT OF PASO DEL NORTE.

*Exports and imports for the year ending December* 31, 1878.

| EXPORTS. | | IMPORTS. | |
|---|---|---|---|
| Total valuation | $60,000 00 | Total valuation | $420,873 46 |
| Chiefly cotton and woolen goods. | | Principal commodities: | |
| | | Silver coin and bullion | $313,381 00 |
| | | Cattle | 59,916 00 |
| | | Wheat | 5,543 00 |
| | | Wheat-flour | 7,244 00 |
| | | Corn | 6,337 00 |
| | | Beans | 4,287 00 |
| | | Sugar | 3,307 00 |

The position of the initial monument of the boundary line between the United States and Mexico, as determined by the commission of 1855-'56, is as follows: Latitude, 31°

47′ 00″; longitude 106° 31′ 23″.5. Our determination of the same point differed somewhat: Latitude, 31° 46′ 58″.54; longitude, 106° 31′ 34″.02. This shows a difference in latitude of 1″.46 or about 147 feet, and in longitude of 10″.52 or about 906 feet. Our determination of the position of the El Paso cathedral showed a remarkable coincidence with that of the boundary commission. As published in their report, the position is, latitude, 31° 44′ 15″.7; longitude, 106° 29′ 00″. As determined by our party, latitude, 31° 44′ 15″.11; longitude, 106° 28′ 59″.77; showing a difference of only 0″.59 in latitude and 0″.23 in longitude. The longitude of the astronomical monument was determined by telegraph, and carried to the other points by triangulation. The boundary commission determined their longitudes by "lunar culminations."

The 4,656 square miles surveyed by the party may be approximately classed as follows:

| | |
|---|---|
| Arable, with irrigation | 132 |
| Grazing, good | 2,984 |
| bad | 652 |
| Timber, large | 439 |
| small | 169 |
| Arid or barren | 280 |
| | 4,656 |

In conclusion, I desire to thank the members of the party for their untiring energy and cheerful co-operation under all circumstances. To Mr. Maxson is due, to a very great extent, the success of the season's work. Mr. Walbridge rendered valuable assistance in the topographical line, and Mr. Kerr as meteorologist and Mr. Phillips as odometer-recorder were all that could be desired.

I am, very respectfully, your obedient servant,

EUGENE GRIFFIN,
*Second Lieutenant of Engineers.*

Capt. GEO. M. WHEELER,
*Corps of Engineers, in charge.*

## APPENDIX D.

### REPORT OF LIEUTENANT WILLARD YOUNG, CORPS OF ENGINEERS, IN CHARGE OF PARTY NO. 2, UTAH SECTION, FIELD-SEASON OF 1878.

OGDEN, UTAH, *March* 17, 1879.

SIR: I have the honor to submit the following report of operations of parties under my charge during the season of 1878:

#### SURVEY OF GREAT SALT LAKE.

Instructions from you were received early in March, at the field-office in Ogden, to organize at once a party for the survey of Great Salt Lake. A plan for prosecuting this work had already been submitted, and in reply your directions were: That a careful meander of the shore-line of the lake and of its islands should be made; that the amount of inflowing water should be determined by measuring all streams flowing into the lake; that observations should be made to determine the surface-evaporation as well as the rise and fall of the lake; that all necessary topographical notes of the country immediately bordering the lake, and of the islands, should be taken.

Soundings were to be made when practicable, but as our operations were confined entirely to the land, and land-transportation only used, nothing in this respect could be done.

The party which took the field March 11, consisted of myself, as executive officer; Francis Klett, topographer; Louis Seckels, meteorological observer and chainman; Corporal John T. Hill, Fourteenth Infantry, chainman; Private M. G. Brenholtz, Fourteenth Infantry, packer; Private Joseph Messer, Fourteenth Infantry, cook and assistant packer; Sergeant F. L. Hoffman, Fourteenth Infantry, was left at Ogden in charge of the observatory, and was to make the prescribed meteorological observations there, and was charged with making the experiments for determining the evaporation and rise and fall of the lake. The instruments supplied were one six-inch Würdemann theodolite, reading to ten seconds; one Y-level; one Young & Sons' topographical transit, reading to one minute; one gradienter, and the necessary meteorological instruments. Five riding, four pack, and two team mules, with a light spring-wagon, were the means of transportation.

The principal streams entering the lake are the Jordan, Weber, and Bear Rivers, and these are the only ones whose discharge was to be determined by regular current-observations. It was only possible, from the small size of the party, to gauge these streams in succession; and as it was desirable that this should be done as nearly on the same date as possible, and as only the eastern and northern shores of the lake could be meandered without the aid of a boat, the mouth of the Jordan River was selected as the initial point most favorable for our work. After determining the discharge of the Jordan, our first care being to find a suitable place for our observations, the regular meander work of the shore-line was commenced.

The surveying party proper, consisting of the topographer and two chainmen, followed, as nearly as possible, the actual shore-line; and an average of seven or eight miles per day was found to be good work. A great deal of soft, sticky mud was encountered, making the walking very difficult and the chain very hard to drag. The meander work along the eastern shore, around the Promontory, and along the northern shore of the lake, was prosecuted almost without interruption, until a point about eight miles south of Kelton was reached. A few days of stormy weather were experienced, and a short delay made at Weber and Bear Rivers to gauge these streams. It being impracticable to continue the work further without the aid of a boat, and as this could not be furnished, the party, after waiting several days in Kelton for instructions, returned to Ogden on May 12. Around the Promontory, and where the shore could be closely followed with the wagon, measurements were made with an odometer instead of by chaining. Three-point stations, to serve as checks to the work, were frequently made. Careful topographical notes of the Promontory Mountains were taken, and two of the principal points occupied as triangulation stations. Careful estimates of width, depth, and velocity of all streams encountered were made, so that the total inflow of water to the lake could be determined. The only streams not observed by us in this way are those entering the lake at its southern end, and lying west of Jordan River, and the few small springs on Antelope and Stansbury Islands.

There are a few springs known to exist below the present level of the lake surface, but of course no estimate of the amount of water discharged by them could be made. The total discharge from all other sources, not including Jordan, Weber, and Bear Rivers, as given by our observations, is 222 cubic feet per second. When it is remembered that these observations were made during the months of March and April, after the streams had begun to rise, and when the springs were well supplied with water from the last winter's snows and rains, and that at this season none of the water was diverted for purposes of irrigation, it is not too much to assume that this result will represent a fair annual mean of the inflow from these sources.

### CURRENT OBSERVATIONS.

In gauging the Jordan, Weber, and Bear Rivers, sub-surface-floats only were used They were made from ordinary five-gallon coal-oil cans, the tops and bottoms of the cans being cut out. Wires were soldered diagonally on the inside to serve as an attachment for the cord connecting with the surface-float. Light slips of pine board were sawed to the proper length and fitted on the inside near the top of the can, to give it sufficient buoyancy. Each can was connected by a fine cord to a small tin elliptical float, carrying a flag. This served to keep the main or sub-surface-float at a constant depth, and the flag marked its course. Opposite each base-line four or more cross-sections of the stream were made, by taking soundings at distances of 10 feet. The streams being narrow, the distances were very accurately determined by stretching from bank to bank a cord marked at distances of 50 and 10 feet, respectively, with white and red rags. These graduated cords, when placed at the extremities of the base-line, afforded a very easy and accurate method for determining the course of each float.

The results obtained are given in the following table. I base my estimate for mean discharge on a study of the character of the channels and on information gathered as to the relation existing between the height of the water at the time of measurement and at the flood and low-water seasons, as well as the probable duration of high water.

| Stream. | No. of floats. | Measured volume, in feet, per second. | Estimated mean volume, in feet, per second. | Remarks. |
|---|---|---|---|---|
| Jordan River—Measured March 12, 13, 1878, at Winegar's Ranch, near the mouth of the river | 55 | 875 | 1,000 | Mid-depth flow only. |
| Weber River—Measured March 22, 23, 1878, at Alma, below mouth of Ogden Creek | 95 | 882 | 1,200 | Mid-depth flow only. |
| Bear River—Measured April 6, 7, 1878, at Corinne | 125 | 2,507 | 3,500 | Mid-depth flow only. |
| Supply from all other measured sources | | 222 | 222 | Estimate of width, depth, and velocity. |
| Supply from Tooele and Skull Valleys and from islands | | | 78 | Estimated. |
| Total | | | 6,000 | |

The mean inflow to the lake for the year 1878 would thus be 6,000 cubic feet per second. This result is not to be relied upon as giving a correct mean. Such would be the case, very nearly, if the sources of these streams were constant springs, and if they were allowed to flow in their own channels throughout the year without being diverted for purposes of irrigation; but, depending as they do largely upon the melting of the mountain snows, an almost daily fluctuation during the spring and summer months is noted, and the amount is, besides, perceptibly decreased during the season of irrigation. During the season of high water the volume is many times that of the fall and winter months, and it is very difficult to form a correct estimate of the mean inflow.

Observations were made by me in March, 1879, to determine the height of the lake surface as compared with its height of the same date in 1878. I find that, in the year thus included, the lake fell 2,575 feet, or about 31 inches. The average annual rainfall for Salt Lake City for the past ten years is over 20 inches, while the rainfall for the year ending March 20, 1879, as taken from the records of the signal station at Salt Lake City, is but 16.02 inches. A marked decrease in the lake's supply is thus shown, both of inflowing water and of rainfall.

An inflow of 6,000 feet would in a year suffice to cover the lake to a depth of 40 inches. Adding to this the total rainfall assumed for the whole lake to be 12 inches, and the fall of the lake surface 31 inches, we have for the total annual evaporation 83 inches.

## EVAPORATION, ETC.

The observations for determining the evaporation and rise and fall of the lake were made by Sergeant Hoffman at Lake Side, near the village of Kaysville. This point was selected as being convenient to Ogden, and, besides, as being distant from any large streams of fresh water and from the mountains.

A wooden pillar, graduated to feet and inches for 5 feet of its length, the zero being at the bottom, was set in the lake, in about four feet of water. On March 18 the water-surface read 1 foot and 9 inches. A large wooden stake, to serve as a permanent reference-mark, was driven near the flag-staff, and its top connected by leveling with the zero of the water-scale. It was found to be 11.075 feet higher than said zero.

For obtaining the evaporation, a wooden box, lined with zinc and made perfectly water-tight, was provided. Its interior dimensions were 24 inches by 30 inches, by 14 inches deep. It was so weighted by counterpoises passing over two grooved standards, in which it was made to work, that, when filled to within 2 inches of the top, it was not more than 3 inches above the lake surface. It was placed in the lake near the graduated pole. The water in the box would thus be subjected, as nearly as might be, to the same influences of temperature, sun, wind, rain, &c., as the water in the lake.

The amount of evaporation was to be taken directly from the box by scale and vernier reading, or was to be determined by measuring the fluid-ounces contained in the box when filled and the amount remaining at the time of observation. The difference, referred to the size of the box, would give, it was thought, a more correct measure than could be obtained by vernier reading. Other necessary meteorological observations were also to be made in connection therewith. The whole apparatus was placed in position on the 18th of March, a clear, calm day, and seemed to work well. Later, however, and after repeated trials, it was found that no reliance could be placed in the results obtained. If the lake was at all rough, the dashing of the waves against the box would soon fill it with the spray thus formed; and on several occasions the box was found totally submerged and sunken, a result, as I suppose, of the undulatory action of the waves, which would not allow a free action of the box in its grooved standards.

On being informed of this failure, other methods were proposed to Sergeant Hoffman which might prove more successful; but he did not find opportunity to carry out my suggestions, his time, until his death, being fully employed at Ogden with Professor André and associates, who were busily engaged in preparations for the transit of Mercury.

The circumstances of the sergeant's sad demise have already been reported in full to you. Sergeant Thomas Knight, Fourteenth Infantry, was afterwards detailed to take the late sergeant's place, but no further observations were made at Lake Side.

## SUMMARY OF WORK DONE.

| | |
|---|---|
| Variations of the needle | 6 |
| Three-point stations | 128 |
| Triangulation and topographical stations | 9 |
| Creeks and ditches measured by estimating width, depth, and velocity | 40 |
| Rivers gauged by current-observations | 3 |
| Miles measured | 255.8 |

| | |
|---|---|
| Divided as follows: | |
| By time and three-point stations | 49.5 |
| By odometer | 60.5 |
| By chaining | 145.8 |
| Camps | 22 |
| Days from Jordan River to Kelton | 54 |
| Days delayed by storm | 9 |
| Cistern-barometer observations in the field | 118 |
| Aneroid-barometer observations in the field | 118 |
| Cistern barometer observations on triangulation stations | 16 |
| Aneroid-barometer observation on triangulation, topographical, and meandered stations | 155 |

### DEVELOPMENT OF THE TERRACE-LUCIN BASE.

In the fall of 1877 a base-line, a little over 24 miles in length, was measured along the line of the Central Pacific Railroad between Terrace and Lucin. Two measurements were made, under the direction of Messrs. Klett and Kintner, civilian assistants. The work to be done by the party under my charge was to level this base, and to so develop it as to connect with the system of triangles to the northward and eastward completed in 1877.

The personnel of the party was the same as that engaged in the survey of Salt Lake. The instruments, field-equipment, and transportation, were also the same, except that no wagon was taken. Triangulation instrument No. 112, by Würdemann, was very much out of order. Application was made to have it replaced by a better one, but this was not done. The results obtained are not, it is feared, as good as could be hoped for in consequence, although great care was taken, by multiplying observations, to eliminate all source of error.

The party left Ogden on the evening of May 23, by rail, and reached Terrace the next morning. On inquiry, it was found that the monument erected by Messrs. Klett and Kintner the previous year at Lucin had blown down, and had been removed and destroyed. Two members of the party were, therefore, at once sent forward to rebuild it and cover it with white cloth, a supply of which had been provided on leaving Ogden. The monument at Terrace was still standing. The work of leveling was at once undertaken and carried forward to completion by Messrs. Klett and Seckels. On occupying the extremities of the base, the monuments were found to be indistinct, even at the most favorable times of the day for observing. It was, therefore, decided to increase their size, and a height was given to them of from 25 to 30 feet, while before they stood but 12 or 15 feet above the ground. On every station but one, where the view was not obstructed by mountains, sights were taken to both monuments. At Pilot Knob the Lucin monument could not be seen, for the day we made the ascent of this mountain proved to be hazy, and the Terrace monument was undistinguishable.

The work of leveling being completed and stations made at the extremities of the base, we proceeded to occupy, in order, the following points: Desert Peak, Pilot Knob, Newfoundland Peak, Clear Creek Peak, Citadel Peak, Deer Peak, and Tangent Peak. This completed the work assigned us, and, returning from the field, we reached Ogden June 20. Topographical notes were taken by Mr. Klett at nearly all the mountain stations, and the heights of all were barometrically determined.

The history, resources, and general geology of the Salt Lake Valley and Desert are too well known from previous reports to require from me any further description.

Mining locations had been made and some work done near South Promontory Peak; at Newfoundland, where there is a district organized; at Silver Islet, or Desert Peak; and in the Clear Creek hills, north of Terrace. At none of these places was work being prosecuted at the time of our visit. Locations were noted on the east side of the Ombey Mountains, in the vicinity of Pilot Knob. On the western slope of these mountains, distant from the railroad about eight miles, and in the State of Nevada, is situated the once thriving mining town of Buell. Work in some of the mines in the vicinity is still carried on, but only to a limited extent. Specimens of ore were obtained only at Newfoundland. These are principally carbonates and sulphides of copper, with some argentiferous galena of low grade. The district has been almost abandoned since 1871.

Following is a brief summary of the work done on this trip:

| | |
|---|---|
| Triangulation stations | 9 |
| Topographical stations | 3 |
| Camps | 14 |
| Days in the field | 28 |
| Days in traveling | 12 |
| Days on stations | 8 |
| Days in leveling base | 6 |
| Days delayed by storm | 2 |

The prescribed meteorological observations were made every night and morning at camp, and barometric readings were taken on each mountain station.

### PARTY II.—UTAH SECTION.

This party, which was organized at Ogden, Utah, in the latter part of July, consisted of myself, as executive officer and field astronomer; Frank Carpenter, topographer; William Hollis, meteorological observer; W. A. Purrington, aneroid and odometer recorder; George Stewart, chief packer; Corporal J. T. Hill, Fourteenth Infantry, packer; and Charles Harris, cook. One man to act as guide, herder, and man of all work was engaged on reaching the field.

The work intrusted to us was the completing of the survey of the country lying within atlas-sheets 73 A, 73 C, 73 D, and 80 A, left unfinished in 1875. Instructions were also given us to continue the work southward from Los Angeles toward San Diego, as far as time and the weather would permit.

We took train at Ogden, with our complete outfit, on the 26th day of July. The point selected for commencing actual field work was Caliente, Cal., and this we reached on August 2. All the supplies for the season were received here. From this point we proceeded to meander the Kern River to its forks, near Kernville, and to survey two small unfinished areas; one lying west and south from Owen's Peak, and comprising the country in the immediate vicinity of Walker's Pass; the other lying north of Kern River, on the slope of the mountains towards Tulare Valley, and comprising the country drained by Posa Creek.

The route of the party from Caliente was down the cañon to the railroad station Pampa, across the foot-hills, and down Cottonwood Creek to Kern River, and thence over the Breckenridge Mountain to the mining town of Havilah. From this point the stage and freight road running from Caliente to Panamont was followed, up the south fork of Kern River and through Walker's Pass, to Coyote Hole, a stage station on the edge of the Mojave Desert. Returning, a new line over the hills and down the Kelso Creek to the town of Weldon was meandered. A trail running down the Kern River Cañon took us to the old mining camp, now abandoned, of Dahlonega. The mines here are said to have been the first worked in Kern County. We were enabled to proceed but little farther along the river beyond this point, as the cañon below here and to its mouth becomes a narrow, rock-bound, and impassable gorge. We therefore turned northward across the mountains and descended to Posa Creek. A few days in this region sufficed for Mr. Carpenter to gather the necessary topographical data, when we proceeded to meander Kern River from the mouth of the cañon to Bakersfield. We then returned to Caliente for supplies.

The foot-hills bordering the Tulare Valley, west of Breckenridge Mountain, and those north of Kern River, were well covered with the grasses of the country, and, where not eaten out by sheep, the feed was abundant. In the other portions of the country traversed by us the grazing was but indifferent. An abundance of fine pine timber was found near the summit of the Breckenridge Mountain, and in the vicinity of Posa Creek and near Caliente the hills were covered with oak, live-oak, and sugar-pine. In the country east of Havilah and Kernville but little timber of any kind was found. Along the south fork of Kern River, and in the valley where the north and south forks come together, there are about 20 square miles of cultivable land, with a sufficiency of water in the river for irrigation. A considerable sum of money would have to be expended to carry water to all this land, which, judging from appearances, is not very productive.

Posa Creek sinks before reaching the plain, and only furnishes water for a few ranches along its banks while yet in the mountains and foot-hills.

Kern River, as it debouches into the valley, furnishes water enough to irrigate about 200 square miles of land. It is being mostly utilized on the plains about Bakersfield, where there are large companies formed which own and control the water-rights.

Leaving Caliente August 25, a line around the north side of Livermore Mountain to the old Tejon Reservation was meandered. From this point our course was through Tejon Pass to the Desert, and thence across the Liebre Ranch to Elizabeth Lake. Here we entered the cañon of Castac Creek, which we followed to its mouth, on the Santa Clara River. Then, crossing by trail the mountains to the south of this stream, we reached the old mission of San Fernando, September 1. This country was visited by parties of the survey in 1875. The only new ground touched by us was the Castac Cañon. The country through which this creek runs, from Elizabeth Lake to within a few miles of its mouth, is almost utterly worthless, being covered with a thick growth of chaparral and other brush, to the exclusion of all other vegetation. Near the Santa Clara the brush runs out, and the hills are covered more or less luxuriantly with herbage of different kinds, affording very good pasturage. A great many sheep are herded here. Bear, deer, and quail abound in the cañon. Near its head, and for some distance below Elizabeth Lake, the rock of the cañon is of a true granitic structure. About midway down the cañon, however, it changes to a kind of dolorite, schistose in structure, and very much tilted and twisted. Still lower it changes to a pudding-stone, and then to a sandstone.

The next unfinished area to be surveyed by us was situated west of our camp at San Fernando Mission, and comprised portions of the San Fernando, Conejo, and Santa Monica Mountains, and of the Simi, Las Posas, Santa Clara, San Fernando, and Los Angeles Valleys. Our time until October 3 was fully occupied in this region in meandering roads and trails, and in occuping topographical and other stations. The sea-coast in the vicinity of Santa Monica for several miles, and from San Buenaventura to beyond Hueneme, was also meandered. The only lava seen during the season was found in the hills at the lower end of the Simi Valley. For description and resources of this region reference is made to the reports of former years.

On the 4th day of October the party left Los Angeles for the San Gabriel Cañon, passing on the way the beautiful San Gabriel Valley and the old mission of that name, said to have been the first established by the Spanish padres in this region. The old church here is in tolerable repair, and religious services are still held there. The surrounding country, which is largely taken up in orange culture, is the most beautiful visited by us during the season. The work in the cañon progressed very slowly, from the almost impassable nature of the trails we had to follow, and especially owing to the absence of grass or forage of any kind for our mules. The four principal forks were meandered as far as it was possible to penetrate with our animals. The extreme western fork, which rises immediately under San Gabriel Peak, was named Joy Cañon in honor of Mr. Douglas A. Joy, geological assistant of division No. 2 in 1875, who in that year traversed the whole distance from San Gabriel Peak to the mouth of the cañon on foot.

There are extensive deposits of detritus and *débris* all along the cañon, which are auriferous, and gold-washing has been and is still carried on to a considerable extent. There was some excitement at the time of our visit about reported rich strikes at and near the Winston silver mine, near the mouth of the cañon, where a true fissure-vein is said to exist, and where there are silver deposits resembling in many respects those near Virginia City, Nev. With the exception of the mining interests and a little pine and oak timber near the summits of the mountains, very hard to get at, the entire country drained by the San Gabriel is worthless, and comprises one of the most dreary and uninviting regions imaginable. From the head of Joy Cañon we made a comparatively easy ascent of San Gabriel Peak, and, although detained there two days by stormy weather (Mr. Carpenter and myself remaining on the peak during that time), we at last succeeded in obtaining all wished-for results. We were just three weeks in the cañon, meandering the stream and occupying the necessary mountain points, and during that time our animals had become very much jaded and worn, so that for a time but short marches could be made. After meandering San Antonio Creek to near its head, and making a topographical station on a mountain west of the cañon and near San Antonio Peak, we took the road leading through Cucamonga to San Bernardino, and reached this latter point November 1. Mining in San Antonio Cañon had just received an impetus from new discoveries made there, and a number of parties were at work washing or prospecting.

At San Bernardino we supplied ourselves with rations for thirty days, from the general stores that had been forwarded by rail from Caliente to Los Angeles, and thence to Colton. The surrounding country is a fertile, well-watered, and delightful valley of fields, vineyards, and orchards, and contains a mixture of American, Spanish, and Indian population. The principal business interests are centered in San Bernardino, though the town of Colton, but three miles distant, and situated on the railroad, bids fair, as the general depot of this region, to rival it in time. We were detained two days at the mouth of Lytle Creek Cañon by a severe storm, the only one experienced during the season. The surrounding mountains were covered with snow half-way down from their summits, and in some places to a depth of 18 inches, but it so rapidly disappeared as to occasion us no other inconvenience than the delay mentioned.

The ascent of San Antonio Peak was made from the head of Lytle Creek on the 10th, and the next day we crossed over the mountains northward into Swarthout's Cañon, camping at Matthews' Ranch, where Lieutenant Whipple and party made a halt in 1875. The rock around San Antonio Peak, and, indeed, throughout this whole sierra, is granitic. The cañon of Lytle Creek towards its head is the most regular I have ever seen, and exhibits signs of extensive glacial action. The east fork of San Gabriel Creek, heading under San Antonio Peak, and just over the divide from Lytle Creek, also shows this same action to a marked degree. Gold placer-mining has been carried on to some extent in Lytle Creek, but the work is now abandoned south of Swarthout's Cañon. On the mountains dividing it from San Gabriel and Rock Creeks, an abundance of fine pine timber is found, interspersed with a little redwood. Water in Swarthout's Cañon is quite scarce, only appearing as springs at different intervals along the cañon. Locations have been made at each of these, and several ranches have been started, where potato-growing is a great success.

After following down Swarthout's Cañon to near its mouth, on the desert, and turning to the east and crossing a low ridge, we entered the main Cajon Wash at its head, the aneroid reading 4,510 feet on the divide at this point. The projected railroad from Los Angeles to Independence was to have run through this pass, and the grading in this vicinity is completed for a distance of several miles. In crossing from the wash to the desert a long tunnel is necessary, and work on this had also been commenced. The wagon road does not follow the main pass for more than half of its length, but turns to the right up a narrow, rocky cañon, and thence passes from its head on to the desert. We followed this road from the mouth of the cañon to a mile beyond Fear's stage station, and then crossed over on to the west fork of the Mojave River. An extensive plain or valley, well covered with grass, along this stream to the forks of the river, affords pasturage for great numbers of cattle and horses. At the time of our visit the range was overstocked, and the grass pretty well eaten down. At the forks of the Mojave we found an encampment of about fifty Pah-Ute Indians, including men, women, and children, very comfortably fixed (though living in wickiups) and tolerably well dressed. They have water ditches constructed to irrigate about 10 acres of land, and this they farm each year. Their principal food, however, consists of pine-nuts and such game as they can kill in the surrounding mountains. Nearly all the water of the river at this point comes from the east fork, and it all sinks a short distance below the Indian camp. I estimate that there is water enough coming out of the cañon here to irrigate a thousand acres, and there is more than this amount of land in the plain below. Of its fertility I cannot speak, though I judge it to be not very productive.

Up to this point the hills were more or less thickly covered with chaparral and other brush, if timber of some kind was not found; but here we encountered the true desert country. The hills to the eastward, which we skirted by following the true desert plain, were entirely destitute of vegetation, except a scattering growth of bunch-grass, and resembled, in their dry, parched appearance, the isolated groups of mountains which rise here and there from the Great Mojave Desert and add to its dreariness and desolation. Farther east, as we ascended the road leading to Holcomb and Bear Valleys, brush and piñon pine were again met with; and, finally, extensive forests of beautiful pine were encountered, stretching eastward as far as Santa Ana Creek and the San Bernardino Mountain, and westward along the summit of the mountains to the Cajon Pass. Several steam saw-mills have already been built, one at Holcomb Valley, the others in the mountains just north from San Bernardino, which supply the surrounding country with lumber. The mining and timber interests of this region are the only ones of any considerable value, though the grassy swamps of Bear Valley afford good pasturage during the summer months. At the lower end of this valley the water collects into a large, shallow lake, which is a resort for thousands of geese and ducks. The principal rock formations are still granitic, though there are some quite extensive limestone deposits, notably in the vicinity of the Green lead mine, west of Holcomb Valley, and in the Lone Valley mining district. There is also some limestone found in the foothills east of Cajon Pass, and on the south slope of the mountains. East of Bear Valley the hills are mostly covered with piñon pine and the higher mountains with pine timber.

From our camp at Lone Valley two topographical stations were made; one on Mineral Hill, so named from extensive mineral deposits; the other on a point near the divide between the headwaters of Whitewater and Santa Ana Creeks From Bear Valley we crossed over the mountain into the cañon of the Santa Ana, and meandered that creek from the fork near its head to near the mouth of Bear Creek, beyond which it was impossible to penetrate; then, crossing the west end of the San Bernardino Mountain, we descended into Mill Creek, at Forsee's Ranch, and from there proceeded to San Bernardino, which we reached November 29.

In Mill Creek there are two or three ranches, where fruit-growing is a principal business. The mills, from which the creek took its name, were destroyed by a flood in 1862, and have not been rebuilt. Forsee's Ranch, here situated, is a favorite camping spot for pleasure parties seeking relief from the intense summer heat of the valley below. In Santa Ana Cañon there are several large *cienegas*, where during the summer a great many cattle are pastured. A large fish-pond was built here at considerable expense, and fish-culture entered into; but it has proved a failure, mainly, I judge, from the want of a market. Besides pine and oak, some very fine cedars are found in this cañon.

Orders were found awaiting us at San Bernardino to disband the party in time to reach Sacramento with our outfit not later than December 12. Four days were spent in the mountains to the north of San Bernardino, to complete the topography of that region; and then, following down the Santa Ana River, we reached Santa Ana December 7. On the 9th our animals, stores, and public property of every description were loaded on to cars and started for Sacramento. Arriving there, everything was ransferred to Lieut. B. H. Randolph, Third Artillery, quartermaster of the survey;

and the work of disbanding, storing, and shipping, carried to completion under the direction of Lieut. S. E. Tillman, Corps of Engineers.

The following list shows the principal observations made by the party:

| | |
|---|---|
| Sextant latitude stations | 9 |
| Main triangulation stations | 2 |
| Three-point stations | 106 |
| Meander stations | 1,571 |
| Monuments built | 43 |
| Variations of the needle taken | 8 |
| Miles measured | 1,176.44 |
| Miles traveled and not measured | 462.25 |
| Camps | 96 |
| Cistern-barometer stations | 176 |
| Aneroid-barometer stations | 1,044 |
| Days on the march | 118 |
| Days in camp | 11 |

Information concerning the mining districts examined will be found under the head of mining notes elsewhere.

Very respectfully, your obedient servant,

W. YOUNG,
*Second Lieutenant, Corps of Engineers.*

Capt. GEO. M. WHEELER,
*Corps of Engineers, in charge.*

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## APPENDIX D (SUB).

### REPORT OF LIEUTENANT WILLARD YOUNG, CORPS OF ENGINEERS, IN CHARGE OF A SPECIAL PARTY ENGAGED IN THE SURVEY OF GREAT SALT LAKE AND VICINITY, FIELD SEASON OF 1879.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
*Ogden, Utah, July 18, 1879.*

SIR: I have the honor to submit the following report of the operations of a special party engaged in the survey of Great Salt Lake and vicinity during the field season of 1879.

The party was organized at Ogden, Utah, and consisted of myself, as executive officer and triangulator; Francis Klett, topographer: Louis Seckels, meteorological recorder and chainman; Sergeant Thomas Knight, Fourteenth Infantry, chainman; Private Joseph Messer, Fourteenth Infantry, cook; Benjamin Brown and Lewis Brown, boatmen; making in all a party of seven men.

The boat chartered to furnish transportation for the party was the Joseph Brown, of Salt Lake, a sloop-rigged yacht of about nine tons burden. We had besides a cat-rigged skiff, which was used in landing and in general coasting where the water was shallow. The surveying party used the latter boat most of the time, as good headway could be made with the oars, even when the wind proved unfavorable for sailing. It drew about one foot of water, while the large boat drew about three feet.

Instruments, rations, and the general camp-equipage having been shipped from Ogden, the party proceeded by rail from that point to Lake Side on the Utah Central Railroad, meeting there on April 22, 1879, the Messrs. Brown with their boats. The general stores were at once loaded on to the boat, and everything placed in readiness to commence the survey work as soon as the weather would permit, it being at that time stormy, wet, and cold.

In plotting the work of last year, a portion of it, from the Jordan River to Lake Side, proved unsatisfactory, and it was therefore decided to run a new line between these points, so as to correct any errors there might be in the old work, and to exercise the men in their duties before reaching new ground.

The weather proving favorable, work was commenced April 22, and from that time on was vigorously prosecuted. Stations were made along the shore at distances of one or two miles apart, with a ten-inch Würdeman transit, and the position of each marked by a strong wooden stake, firmly driven into the ground and appropriately marked and numbered. A meander line was run between these points with a Gunter chain and a Young & Son transit by the topographer and his assistants, which afforded the means of gathering all necessary data regarding the conformation of the shore.

The work of running this meander was very fatiguing and trying to those engaged in it; the walking, almost without exception, being difficult, either from water, mud, or loose sand. For this cause and for the reason that the work of chaining would, of necessity, be frequently interrupted along the western shore, and especially around the rocky shores of the islands, this method of conducting the meander was not continued beyond the northern end of the Stansbury range of mountains, near Skull Valley; but from that point forward three-point stations with the large instrument were made more frequently, and the shore line between them sketched in and fixed by cross-sights. This change enabled us to make much greater progress, and it is thought the results will prove even more satisfactory.

On May 26 we reached the point where work was discontinued in 1878. Each of the principal islands in the lake was then visited in turn, its shore meandered, and the highest point carefully occupied as a triangulation station. Stations were then made with the large instrument at three different points on the promontory, and at two points on the eastern main shore, to serve as checks to last year's work The shore line of the lake eastward a few miles from the mouth of Bear River, which was left unfinished in 1878, was filled in, and the river itself meandered from its mouth up as far as Corinne. This latter point was reached June 20, and here we dismissed the boat and boatmen. Thence proceeding by rail, we arrived in Ogden June 21.

Preparations were at once made to visit Mount Grant and occupy it as a main triangulation station in connection with our work. This was done on June 28, and on our return Mr. Klett and myself reached Ogden again June 30. The other members of our party, Sergeant Knight and Corporal Brenholtz, Fourteenth Infantry, delayed at Lake Side to assist in construction of an evaporation tank for determining the lake evaporation, and did not reach Ogden until July 2.

A meander of the Weber River, from the Utah Central Railroad bridge at Ogden to the lake shore, was also made.

Observations at the Ogden office are now being made during three days of each week, to determine the evaporation from the lake surface. The results thus far show a daily average of about ⅜ of an inch for the month of July.

While on the lake some care was exercised in gathering specimens of lake water, salts, fossils, &c., to add as far as possible to the general knowledge of the country visited by us.

Lines of soundings were made whenever possible without interfering with our other duties. Time, however, did not permit any systematic work in this regard. The water brought from the lake—in all, twelve bottles—taken from the bottom, mid-depth, and surface, respectively, at four different points in the lake, and the specimens of mud and salt, have been submitted to Professor Kingsbury, of the Deseret University, Salt Lake City, for analysis.

Following is a summary in brief of the results obtained by the season's labor:

Points occupied as main triangulation stations: Mount Grant, Antelope Island, Monument Point, Skull Peak, Stansbury Island, Lip Peak; total, 6.

Points occupied as secondary triangulation stations: Dolphin Island, Carrington Island, Gunnison Island, Hat Island, Miller's or Fremont's Island, Strong's Knob; total, 6.

| | |
|---|---|
| Number of three-point stations with large instrument (Würdeman, No. 160) | 193 |
| Number of three-point stations with small instrument (Young, No. 5063) | 218 |
| Number of pointings made on primary and secondary triangulation stations | 2,590 |
| Average for each station | 216 |
| Number of points occupied as meander stations | 435 |
| Number of three-point stations at land-office stakes or marks | 2 |
| Stone monuments built | 50 |
| Variations of needle by Polaris | 7 |
| Needle-readings from triangulation points | 4 |
| Number of miles chained | 92.27 |
| Number of miles traveled and not chained | 300 |
| Camps made | 42 |
| Points occupied as cistern-barometer stations | 12 |
| Points occupied as aneroid-barometer stations | 2 |
| Highest altitude noted (Mount Grant), feet | 10,500 |
| Lowest altitude noted (lake surface), feet | 4,200 |
| Mining camps | 1 |
| Days in travel | 55 |
| Days in camp | 15 |
| Streams gauged | 16 |
| Rock specimens collected | 10 |
| Ore specimens collected | 6 |
| Fossils collected | 12 |
| Botanical specimens collected | 22 |

| | |
|---|---|
| Zoological specimens collected, some in water | |
| Larvæ of insects, cans | 2 |
| Mud from lake bottom, bottles | 2 |
| Number of soundings recorded | 500 |
| Deepest sounding made, feet | 39 |

Very respectfully, your obedient servant,

WILLARD YOUNG,
*Second Lieutenant, Corps of Engineers.*

Capt. GEORGE M. WHEELER,
*Corps of Engineers, in charge.*

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## APPENDIX E.

### REPORT OF LIEUTENANT ROGERS BIRNIE, JR., ORDNANCE CORPS, IN CHARGE OF PARTY NO. 1, COLORADO SECTION, FIELD SEASON OF 1878.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE ONE HUNDREDTH MERIDIAN,
*Washington, D. C., March* 15, 1879.

SIR: I have the honor herewith to submit a report of operations of Party No. 1, Colorado Section, for the field season of 1878.

The party to which I was assigned was organized at Fort Garland, Colo., and left that place for the field on the 26th of July. The following persons made up the party: Lieut. R. Birnie, jr., executive officer and field astronomer; Mr. Louis Nell, topographical assistant; Mr. John A. Hasson, meteorological observer; Mr. G. H. Schleicher, meteorological observer; Mr. E. W. Lyon, odometer recorder, with Felix Burgess and E. W. Davis, packers; Thomas Wells and John Johnson, cooks; and J. B. Grant, laborer. Mr. E. Gillette, jr., afterward joined us at Santa Fé, N. Mex., August 3, 1878, and throughout the season performed the duties of assistant topographer.

The instruments assigned to the party or received during the field season and used by us, were, Sextant No. 1475 Stackpole & Bros., and artificial horizon, No. 11; theodolite No. 123, Buff & Berger (with adjustable standards), reading to 10″; theodolite, No. 1649, Stackpole & Bros., reading to 20″; transits, Nos. 4951 and 4952, Young & Sons, reading to 1′; compensated steel tapes, Nos. 1 and 7; one odometer vehicle, single wheeled; odometers Nos. 10, 15, and 16; field compass, No. 8, and Abbott compass, No. 11; cistern barometers, Nos. 1988, 2159, and 2161; aneroid barometers, Nos. 2088 and 2097, with attached thermometers; pocket thermometers, Nos. 17 and 24; psychrometers (sets), Nos. 5, 16, and 20; maximum and minimum thermometers, Nos. 6 and 14.

The party was designed to work in Southwestern New Mexico, which necessitated a march of over 400 hundred miles from Fort Garland to reach its field of work proper, but en route some old work was to be checked and the country between the Rio Grande about Albuquerque and the Puerco was to be traversed with reference to its topography and the routes of travel from Albuquerque west toward Fort Wingate.

Enough rations were taken at Fort Garland to last the party as far as Sante Fé, to which place we first proceeded. The meander was begun at the ferry near the mouth of the Trinchera, and thence Mr. Nell went through the lower settlements on the Conejos and returned to the Rio Grande at Myers' ferry. An old stockade, said to have been made by Pike near the Conejos, was sought for, but its site could not be certainly fixed. From Myers' ferry a meander was run, following as closely as possible along the west bank of the river, to the ferry and ford at Cieneguilla. Cattle trails were found the most part of the way, but no travel follows that route. The river flows through a deep and rugged cañon—the bank at San Cristobal crossing, 600 feet high, may be taken as an average. Cattle crossings are found opposite Los Cerros, near San Cristobal, and at the mouth of the Arroyo Hondo. From Cieneguilla to Santa Fé our route was over the main road, which had been surveyed and measured by your parties in previous years.

At San Ildefonso, Mr. Nell with a small party left us to survey the cañon of the river between that place and Peña Blanca. At Santa Fé I made arrangement for rations for the party during the season, and our barometers were there compared with those of the Signal Office..

We left August 6, and marched to Peña Blanca where Mr. Nell arrived two days later. He had strictly confined his route to the cañon of the river from San Ildefonso down, and had been compelled to travel a good part of the way along the rocky slopes, without trail and oftentimes crossing and recrossing the river. He made an accurate route survey of this exceedingly rough cañon. Peña Blanca was a suitable place from which to enter the country that we desired to survey, between the Rio Grande about Albuquerque and the Puerco. The party accordingly marched southwest from Pena Blanca toward the little plaza of San Francisco on the Puerco. The meandered route crossed the river at Peña Blanca, where there is a good ford—followed down the west bank a few miles to Cubero and thence was over a little-used trail to the pueblo of Santa Clara on the Jemez.

Crow Spring, apparently only a water-hole but having permanent water, was visited; it is in the lava bluffs of one of the short cañons that cut up the cliffs on the west side of the river in this vicinity, and about one and three-fourth miles west of Cubero. It can scarcely be made of use except for cattle, though there was local talk of the advantage of a road crossing the Rio Grande at Cubero and passing this water, in preference to the established road through Peña Blanca toward San Ysidro Springs, this latter being very sandy. Near this water-hole was shown me the bed of what could only be a very old and long-since disused road; the rough lava rocks had been well cleared to either side, but now were fallen back, while there appeared a well-worn route, making a straight course nearly due east and west, and visible for a mile or more from our point of observation. I would incline to attribute its origin to the Indians, as it connects apparently the Indian towns on the Rio Grande with those on the Jemez, but in that case the amount of intercourse between the two places, as probably also the Indian population and power, has largely decreased. Indeed, the pueblo of Santa Clara presented to the traveler a most marked example of stagnation and, inferentially, of decay. It is built on the bank of the Jemez, where the stream-bed is a sand-flat nearly a mile wide, and the little rivulet of muddy water in it seemed scarcely to know what course to take; on the town side, the sloping bank on which it is built extends back a few hundred yards to the lava cliffs; on the opposite side, a few scattered cedar trees struggle for sustenance in a ridge of sand-hills; vegetation seems to have deserted the place; there were no gardens, because there is no water to irrigate in the dry season. One herd of about 40 cattle was brought to the corral in the evening, and there were numerous sheep and goats, so that all the wealth of the town semed to be their herds. We got a little corn for our animals, which must have been obtained by trade, or perhaps their cultivated fields were distant from the village. They could speak a little poor Spanish, but no English. There was a church and a priest's house, kept ready for the padre at his visit. Their food consisted principally of milk and corn, cooked and made up in various dishes. The isolation of this town, apparently due more to the desire of its inhabitants than its position (for it is less than a score of miles from the towns on the Rio Grande), made it for me an object of striking interest.

Continuing southwest from this pueblo, we passed through the sand-hills along the Jemez and crossed an elevated table-land, sloping toward the Rio Grande, with good grazing. About five miles from the Puerco, the well-defined ridge that runs parallel with it and forms the divide toward the Rio Grande was crossed. On the Puerco slope, and about three miles from the river, we passed Alum Spring. The Puerco Valley was reached just after it had been visited by a severe rain-storm. The alkali mud near the stream was in places nearly knee-deep; the water, totally unfit for use, was flowing in a narrow, deep stream between high clay banks. The character of this stream makes it dangerous to cross except at well-known fords.

From the Puerco we returned to the Rio Grande at Albuquerque, taking three different routes. Mr. Nell passed over a portion of the road that leads from San Bernardino to Salazar, and connects with the Santa Fé road to Fort Wingate through Pena Blanca; the most direct road from San Francisco to Albuquerque was taken by Mr. Gillette; the third meander was through San Ignacio to Albuquerque. There is a ford of the Puerco, at San Ignacio, and thence a route leads west toward Cebolleta and Wingate. The crossing at Albuquerque may be made by ford or ferry. The ford is very dangerous, and the character of the banks and stream-bed makes an exceedingly poor place for a ferry. In traveling from Albuquerque south, the river may be crossed at this point and the road down the west bank taken, or the road through the meadows along the east bank may be taken to the ford at Isleta, which is an excellent one. This latter road is somewhat sandy in places, and in this respect perhaps somewhat inferior to the other.

From the ferry at Albuquerque, in addition to the road toward Wingate via San Ignacio and the road down the river, is the direct road to Wingate, which crosses the Puerco about eight miles below San Ignacio, at San Luis Rey; Mr. Nell took this road to the Puerco, followed down that stream to intersect the road from Los Lunas toward Wingate, and thence proceeded to Los Lunas, where I had gone from Albuquerque with a portion of the party, by way of the ford at Isleta. We had thus crossed the strip between the Rio Grande and the Puerco by six different routes, and obtained thorough and reliable data concerning its topographical and economic features. There are a number of old roads, but the two principally used between Santa Fé and Wingate are first that via Peña Blanca and San Ysidro, and second, that by the ford at Albuquerque and San Luis Rey bridge on the Puerco. Neither of these roads was followed by us far enough to determine its merits.

The travel to Camp Apache, Arizona, from the railroad termini at Alamosa, Cal., and Trinidad, if not through Fort Wingate, leaves the river at Los Lunas, and near Saint John's, on the Little Colorado, intersects the Camp Apache road from Fort Wingate. Later in the season we traversed the part of this road that lies between Rita Quemada and Saint John's, but did not go over any of the portion between Los Lunas and Rita Quemada, which is said to be very destitute of water in the dry season. From Los Lunas we followed the main road along the west bank of the river to Alimillo. My object was to traverse the North Star road—a new military road that leads from Fort Bayard north and passes directly through a portion of the country we meant to survey. Properly this road meets the Rio Grande near the mouth of the Puerco, but that portion between the Socorro Forks, near Pueblo Spring and the Puerco, had been surveyed by Lieutenant Morrison's party in 1877. I therefore went to Alamillo, and took the cross-road to the Socorro Forks by way of San Lorenzo Spring. From Pueblo Spring to Monica Spring we traveled over a road meandered by Mr. Thompson in 1873. Monica Spring is in atlas sheet 84 A, the eastern portion of which had been partly surveyed by Thompson's meander, checked by triangulation in 1873, and completed by close work by Morrison in 1877, but the only work done in the portion west of the ridge of the Mimbres Mountains had been a meander by Sommers in 1873. Thompson's and Sommers' surveys had been plotted, and having with us copies of these, we were enabled to see what had been done. From Monica Spring to Fest's Ferry, which was made the next objective point, a very circuitous route was taken, one however that served well the purpose for which it was undertaken, viz, to develop the mountainous, and consequently the difficult portion of the country we had to survey. It was rather in the nature of a reconnaissance, and indeed could not be much else, as at this time (August 20) the rainy season commenced, and we had rain nearly every day during the succeeding two weeks and until we reached Fest's. Detailed topography was afterward obtained where necessary, as we revisited the country at a better season, when working up the adjacent territory.

The North Star road was our general course from Monica Spring to Magruder's, or Upper Mimbres, near Georgetown. It follows the old road to Luera Spring as far as the Point of Rocks, and then takes a southerly course into the western slope of the Miembres Mountains, crossing the eastern branches of the headwaters of the Gila and comes on the Mimbres near McKnight's ranch, follows down this stream a few miles to Magruder's; thence there is a well-traveled road to Georgetown, Bayard, and Silver City.

From Monica Spring Mr. Nell meandered the trail through the western hills of the San Mateo Range to Ojo Caliente and thence the trail to Shaw's ranch, on the North Star road. The rest of the party followed the road to the forks of the Patterson road across San Augustin Plain from Ojo Caliente, thence along this road to the plain, skirted the edge of this plain a few miles toward the south, and thence proceeded to Shaw's ranch across the open grassy country, where head the extreme (though dry) drains of the Gila River; by this some twelve miles of the road was not traversed (at this time).

I had desired to cross the Mimbres Range to Fest's Ferry with a portion of the party about the latitude of the ferry, but the ground was so soft that it was impossible to travel off the road, and no traveled route across the range exists between Shaw's (over the trail to Ojo Caliente) and the one we finally took, which leaves the Mimbres some eleven miles below Magruder's and crosses the range near Mule Spring. This trail is the shortest traveled route between Magruder's and the new mining town of Hillsboro. From Hillsboro we went by trail to Palomas, and thence along the river road to Fest's Ferry.

This point had been selected as the best adapted for carrying out your instructions in regard to "finding a practicable route across the main divide of the continent between the Rio Grande and the head of the Little Colorado, so situated as to be the most direct possible between El Paso and the head of the Little Colorado." It was believed that in the ridge of the Mimbres, parallel to the Rio Grande on the west, there was no practicable pass between Ojo Caliente and where the range merges into the plains to the south near old Fort Cummings. This supposition was found to be correct, except that a route somewhat similar to, but not so good as, that by way of Ojo Caliente was found by Mr. Nell to be practicable by the head of the Cuchillo Negro. At Fest's a supply of rations and an Indian pony, to replace one that had died, were received from Fort Craig, so that two bell mares were available, and the pack-train could be divided.

The party was divided. I took with me Messrs. Gillette and Lyon, and E. W. Davies and Johnson as packer and cook, to make the party to go to the Little Colorado. The rest of the party were left with Mr. Nell to continue the regular topographical work. Mr. Nell was instructed to work southward between the Rio Grande and the summit of the Mimbres in 84 C., and afterward west from the river toward Fort Bayard, in the southern part of the same sheet. We were to meet at Fort Bayard on my return about the middle of October. From Fest's, by way of Ojo Caliente, was to be my outward route; on the return the drainage of the San Francisco (a branch of the Gila) was to be made available to find a route from the Little Colorado to the vicinity of Silver City or Bayard, whence the plains lying south of the Mimbres Mountains present no obstacle to a route to the Rio Grande at Mesilla.

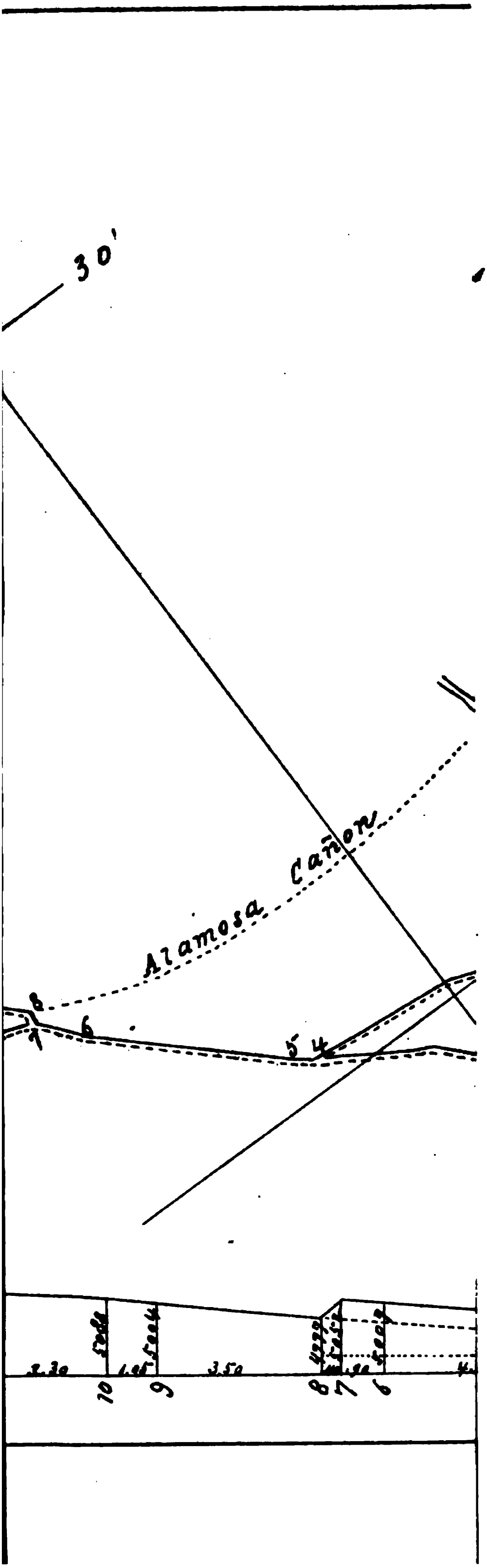
Both divisions of the party left Fest's on September 7.

## TRIP TO THE LITTLE COLORADO AND RETURN TO SILVER CITY.

The accompanying map shows the route taken by the Little Colorado party in going toward that river and the distances, the profile giving the elevations. The other routes of this party meandered are those across the Datil Mountains, and about Tulerosa; and the return route to Silver City by San Francisco River are not especially mapped, no well-defined route being developed by them.

At Fest's is a ferry and a good ford at low water; several roads converge to it from the Jornada del Muerto or the plains on the east side of the river. They approach Fest's through the gap in the Caballo Mountains. The point is a very good one as to approaches from that side, and a better road-bed can be had from El Paso to Fest's by the Jornada del Muerto than by the river, owing to the heavy sand always near the river, and as the plain presents a more even surface. The map shows the outward route. It leaves the river at Fest's and passes over gradually-rising ground until a high grassy plain is reached, some six miles from the river; crosses this plain in a northwest direction until the abrupt bank of the cañon Alamosa is reached. Down this a road could be constructed at any desired grade. Once in this cañon, its drain conducts one to the low divide to the plain of San Augustin. Between the town of Cañada Alamosa and the government post at Ojo Caliente the cañon is in many places very narrow and somewhat winding; a stream some six feet wide and three or four inches deep flows through it. Apparently there would be danger of wash in the cañon at high water, but the wagon-road now passing through it has been used for a number of years. There is little wash, and the trunks of the trees and bushes do not evidence high water, and scarcely corroborate the story of the water having flowed with a depth of several feet throughout the narrow parts of the cañon within a few years past. Still it is certain that great care would be necessary to protect a road built through this cañon from washing. On going up, the cañon proper ends near the hot springs, which are situated in the little valley just above the opening. This opening (or entrance in going down) is remarkable, being like a narrow gateway in the rocks, scarcely more than 30 feet wide and with perpendicular walls a hundred feet high or more. The water from the springs which form the stream makes a shallow rippling flow that completely covers the floor of the gateway. In the open cañon below and 24 miles on the route from Fest's is the town of Cañada Alamosa, a Mexican town of perhaps 100 inhabitants, who simply cultivate the flat, here a half mile wide, using all the water of the stream for irrigating purposes. The ground is productive; several hundred acres are under cultivation. A few miles above the town the cañon narrows as stated. A stunted growth of wood appears on the banks, but from Ojo Caliente good timber can be reached within a few miles. A sawmill was formerly in operation here, but is now removed. Throughout the cañon the stream is shallow and in no place cuts out the bed.

In September, Ojo Caliente was the agency for about 300 Indians, held there as quasi prisoners of war, deprived of their arms, under charge of Lieutenant Cummings, of the Fifteenth Infantry, with a guard of some fifteen soldiers. The buildings are good, consisting of two sets of officers' quarters, a small barrack, a trader's store and house, and a good corral. The place cannot but impress one for its beauty and utility. The warm springs, several in number, with a temperature of 85°, are on the slopes of the low hills a little north of the opening of the cañon and about a half mile from the buildings, which are on the south side of the main drain. The warm springs furnish the most of the water of the stream, but there are copious cold springs near the buildings. From the west several broad, open, but dry drains, filled with fine grass, converge at the post. It is up the longest of these, from the northwest, that the road leads toward the Little Colorado. After Ojo Caliente, the next water on the main road is Luera Spring, after the southern arm of the San Augustin Plain has been crossed. In going from Ojo Caliente, we first pass the fork of the road (Patterson's) that forms the shortest road to the Tulerosa Pass. A limited supply of water will be found at a spring on this during the greater part of the year a couple of miles from the forks. In this vicinity there is good timber. Shortly after the divide to the plain is passed, are seen the forks of the road to Point of Rocks; next, the North Star road is crossed at right angles. The direct and best route would pass through the low hills, leaving Luera Spring several miles to the south, but it is necessary to visit this place for water. Plenty of timber is found about this spring. At present, the spring being filled up, the water supply is very limited. The next water is the Encinosa Spring,


30'
Alamosa Cañon
8
7
6
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2.30
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with a level plain to cross to within a mile and a half of the spring. A road forks to the Tulerosa Pass, a couple of miles from Luera, and on the west side of the plain the direct road from Pueblo Spring (or Socorro) to the Tulerosa Pass is crossed.

Encinosa is an abundant spring; small oak trees grow about, and fine pine timber can be had from the slopes of the Horse Mountain, a few miles to the west. Leaving Encinosa, the road traverses hilly country for several miles, but again enters the long, dry, and gently-sloping drain that is crossed where the road left the San Augustin Plain, plainly giving an excellent grade if we pass around to the north of the hills about Encinosa, but in this case the road would not pass the spring by a mile or more. Our road now follows one fork of this drain up a gentle declivity to the Continental divide, which is crossed a few miles to the southwest of a well-marked, square-topped mountain, called El Creston. On the west side, the road descends somewhat abruptly for about a half mile; then the slope is gentle to Rito Mangas, where is an abundant spring, and the road enters the drain of the Burnt Fork of the Little Colorado. For several miles on the west slope and adjacent to the road all the way from Encinosa to the divide is an abundance of fine timber, much of that about the divide being of a suitable size for telegraph-poles.

On the east side, several miles from the divide, is passed a growth of willows, where water can apparently be had by digging, but the amount would probably be small. From Rito Mangas to Carrizo Spring, or about 17 miles from Saint John's, the road follows or is adjacent to the bed of the Burnt Fork, and its gentle slope leaves no question about the grade. At Rita Quemada is another large spring, forming a stream that runs for several miles as at Rito Mangas. At both these places Mexican settlements have been established within a few years. There are three or four houses at Rito Mangas, and perhaps twelve at Rita Quemada; probably 50 acres are under cultivation at the former place, and four times as much at the latter. At Rito Mangas are to be found the first settlers after leaving Ojo Caliente (a cabin has been put up at Encinosa, but was, at the time we passed, unoccupied). As before stated, we intersect at Rita Quemada the road from Los Lunas to the Little Colorado. No large timber is found near the road to Saint John's after leaving the vicinity of Rito Mangas, but the road frequently passes through growths of stunted cedar. After Rita Quemada, the next point of interest is Salt Lake. Shortly before reaching it a road forks to the left that leads to Milligan's on the Little Colorado, by way of Coyote Spring. The road passes just along the north side of the Salt Lake, and from it one can look down into a depression covering several square miles, the lowest parts of which are covered by the waters of the lake, a hundred feet or more below the general surface. The depression has evidently been formed by volcanic action; a couple of small black cones (craters) rise from the water. In one of these is said to be a small lake with water of much greater saltness than the outer lake. The proportion of salt in this water is not known, but is very great, and the bottom of the lake is covered with a thick layer of salt, to obtain which it is only necessary to throw out the sediment on the beach and wash with clean water. It is the source of salt supply for a large area of country—among others the Zuñi Indians, who are said to hold the vicinity in great awe. A spring of pure water issues from the bank of the depression near the west side of the lake; we did not visit the spring. After leaving the lake, in a few miles, the road passes a number of fresh-water lakes—shallow, but quite extensive, and with *apparently* enough water to last through the year, but it is believed they would be quite dry in May and June. The first permanent fresh water convenient to the road, after Rita Quemada, is found at Tule Spring, in the immediate vicinity of which there is no wood. Shortly after this the road leaves the drain and crosses the hills to La Pilla, and thence to Saint John's. The drain of the Burnt Fork continues in a northwest direction, intersects the Zuñi River several miles from its mouth, and with the Zuñi reaches the Colorado some 15 miles below Saint John's; thus indicating a natural grade to the Little Colorado. Adjacent to the present wagon-road from Carrizo to Saint John's, the hills are rough enough to make the grading of a railroad difficult, particularly on the slopes toward the river; for here we cross a ridge of broken hills, rapidly falling several hundred feet to the plain adjacent to the river. A wagon-route to Apache could probably not be better located than the present road, but a railroad having in view extension down the Little Colorado would undoubtedly find a better route to follow the drain. We passed over the portion of the road in the Burnt Fork just after the rainy season, and found its bed in many places very soft and miry, but this objection would, I think, not exist out of the months of August and September.

In going over this route I think any one could not help being impressed with its directness, its grade, and the character of its bed, with little exception. The Continental divide can be crossed by either a rail or wagon road without difficulty. The route is generally well watered, and much of it well timbered, while from Ojo Caliente to the Little Colorado there would be no bridging and little cutting to make, even for a railroad. A direct line from El Paso to the mouth of the Zuñi will be found to pass not more than 35 miles from Fest's Ferry, the point at which we left the Rio Grande Valley to cross the mountains. It will be seen that this direct line cuts through the most inaccessible parts of the Mimbres Mountains, making it necessary to pass either to the north or south of this group. This route by Fest's is to the north. As stated, Mr. Nell found that a good grade for a road could be established from the Rio Grande, by way of the Cuchillo Negro, through the mountains to Shaw's Ranch on the North Star road. Other observations in the country north and west showed that this route might be continued to connect with that by way of Ojo Caliente at some point in the San Augustin plain. With a view, however, to a route to the Little Colorado from the Southern Rio Grande by this way, it would be necessary to follow up the Rio Grande as far as Palomas; thence the land between that stream and the Cuchillo Negro could be crossed to the drain of the latter. To leave the Rio Grande below Palomas and to attempt to reach the Cuchillo Negro would necessitate the crossing of one or more of those terrible cuts that the streams flowing into the Rio Grande in this vicinity make in the gravelly table between the river and the Mimbres Mountains. Between the head of the Cuchillo Negro and Shaw's there is a great deal of marshy land, and the route through the cañon would be less direct than the Cañada Alamosa. Then from Shaw's to the San Augustin plain the route would necessarily be either difficult or circuitous. I conclude that the Cañada Alamosa offers a route quite as short as the other and much easier, there being already a good wagon-road, while there is not even a trail by the Cuchillo Negro.

Near La Pilla is crossed the boundary line between New Mexico and Arizona. Saint John's is a town of about 200 inhabitants, most of them Mexicans. The roads from Wingate and from the Rio Grande (Los Lunas) to Apache join at the town. The Little Colorado, here a stream some 12 feet wide and 8 inches deep, is crossed by a ford. The road to Apache afterward passes by Cave Spring, &c.

A road leads up the stream toward Springerville, about 30 miles distant. We took this route to examine the valley of the stream. Six miles from Saint John's is found two remarkable springs, called "Salt Springs." Both present a circular surface of water; the largest is about 20 feet across. About the springs the surface is a sedimentary rock, probably lime, formed by deposits from the water, which is not cold. Near the water's edge the rock has formed most rapidly, and presents a wall which is now more than a foot above the surrounding surface. The water flows in small quantity over the edge of the wall, which on the interior is nearly perpendicular. The deeper of the two springs is 40 feet. All around the springs is an alkali marsh, but the sedimentary rock has made a solid footing extending in one direction about 100 feet from the springs. The two are about 40 yards apart. A ranch has been built close to the springs, and is inhabited. The water is not unfit for use, and is drunk by cattle. A few miles above these again, on the same side of the stream (the west), is found a similar series of springs, called Tule Springs. The country about is rough, and cliffs 50 to 100 feet in height rise near the stream, sloping to the higher country on either side. The stream occasionally flows through cultivable valleys, containing from a few acres to several hundred. Evidences of cliff-dwellers are numerous. An old burial cave was found near Tule Spring, but was burned out by some careless or superstitious visitors. Old pottery may be found on the hills, and remains of stone dwellings.

A Mexican living at Tule Spring is now using to irrigate his land a ditch of stone. The water used is derived from the Tule Spring, and the ditch has been so long in use that it is, so to speak, fossilized. The present owner knows nothing of who made it, and, with reason, attributes it to the old inhabitants. Lying on the surface of the ground near by are the remains of another ditch, the segments of trough-shaped stones being in position for 100 yards or more. A few settlers are found along the stream. The road is difficult, encountering a number of hills, and within 12 miles of Springerville leaves the stream and traverses a high lava mesa. The stream cuts through this in a narrow, deep cañon, having in one place an extended and rapid fall. To construct a good wagon-road would require much labor.

Springerville is a thriving and growing settlement, situated in a beautiful valley of the stream. There are probably 150 inhabitants, a number of whom are Mexicans, but the improvements are due to Americans. Mr. Milligan was one of the first American settlers, and owns a ranch and mill. A road through the Datil Mountains, from the San Augustin plain, bears his name. From Springerville the road continues to Camp Apache.

The Milligan road is not used for through-travel from the Rio Grande. The road which branches from the Saint John's road at Salt Lake joins the Milligan road at Coyote Spring and passes through Springerville, but the greater portion of the travel is by way of Saint John's to Apache.

The Tulerosa Pass had been supposed the best through which to cross the Continental divide; in going out, however, we had left it quite to the south. To reach the Little Colorado at Springerville from the San Augustin plain had been my original intention, but the route by the Mangas Pass had been found so direct and good that it was first traversed. Even to come upon the Little Colorado at the mouth of the Zuñi, 45 miles below Springerville, gives a most direct route to continue down the Little Colorado.

We proceeded, however, to examine the Milligan road and the Tulerosa Pass, partly with a view to a route from San Augustin plain, and partly to find a route from Springerville to the Tulerosa Creek, which, being a tributary of the San Francisco, would, if it could be reached, offer a passage from Springerville, by way of the San Francisco, to Silver City, which I had before planned as a return route.

A trip was made from Springerville, over the Milligan road, to the San Augustin plain. Returning to Springerville a circuitous route was taken. We crossed the pass to Tulerosa, looked for a route up Apache Creek, and, failing in this, kept west along the head of the drains of the San Francisco, and tried (from Paria's Spring) the pass of the Datil Mountains at the head of one of the drains of the main stream, which, passing by the new settlement of Las Lentes, cuts through the San Francisco Mountains in a deep gorge.

Afterward, from Springerville, a final route was examined to the drains converging at Las Lentes, by passing from Springerville up Nutrioso Creek and by the west side of the Escudilla Mountains, where the most northwesterly branch of the San Francisco was headed and followed down to Las Lentes.

Both routes from Springerville to Las Lentes were found difficult; that by the east of the Escudilla, and which would fork from the Milligan road between Cienega Amarilla and Oak Springs to cross a low pass of the Datil, is generally the best, although a few miles longer. The other route already has a tolerable wagon-road from Springerville to Bush Valley, which is near the head of the northwest branch of the San Francisco; but from Bush Valley to Las Lentes the country is well nigh impracticable for a road of any kind, without a great amount of labor. At present a very rough road passes along on the north side of the stream. No natural road could be had close to the stream, which for a good part of its course passes through narrow rocky cañons. But any well-graded route by Las Lentes to the Lower San Francisco must pass through the gorge of the stream in the San Francisco Mountains.

A personal examination of this gorge showed it to be impassable. For a couple of miles it narrows to a mere crevice, with perpendicular walls of rock, being several hundred feet in height and the water of the stream completely filling the winding crevice from one rocky side to the other.

To return to the Milligan road and the Tulerosa Pass: The grade of the road, although it might be improved in places, cannot be made good, and some bad, rocky places cannot be avoided. The Tulerosa Pass is essentially a southwest one, and while it offers an easy route from the San Augustin plains to the Tulerosa Creek, and hence gives access to the basin of the San Francisco, it in no way offers a pass to the Little Colorado. The rough country about where the Tulerosa Creek heads in the southwest angle of the Datil Mountains and the Continental divide, the Datil Mountains themselves, and the cut-up, dry, mesa country to the north of them, combine to make a well-graded route from the vicinity of Old Fort Tulerosa to the Little Colorado a difficult thing to accomplish.

As before stated the final attempt to find a route from Springerville and follow down the San Francisco was made by Nu rioso Creek (which enters the Little Colorado at Springerville), thence down the San Francisco to Las Lentes. From Las Lentes to the settlements of San Francisco, where the Tulerosa joins, great difficulty was experienced in traveling with only loose pack-mules. It was impossible to go through the gorge of the stream, and to cross the San Francisco Mountains, which, on their south side, fall in a succession of upturned strata bluffs where only a dim game-trail could be found in places, and the pack-train was nearly three days in traveling a direct distance of about fifteen miles.

Some idea of the rough character of this country can be had from what has been said, but without a good map it is difficult to conceive how effectually nature has wrought to prevent man from traveling whither he may list. The headwaters of the San Francisco, including the Tulerosa, heading in the Escudilla and Datil Mountains and afterward flowing through the San Francisco Range, which is south of and generally parrallel to the others, are encased in narrow, rocky cañons, often boxed, and the country about there can scarcely be described by saying that it is very rough. But this rough country is not without redeeming features, as much of the basin between the Escudilla, Datil, and San Francisco Ranges is made of open grassy country and pleasant valleys. Las Lentes, a small Mexican settlement, is in this basin. Fine timber is growing over the Escudilla, Datil, and on the north slope of the San Francisco. Occasionally fertile valleys are found along the streams. The Nutrioso is fast settling up, and in Bush Valley, before mentioned, a thriving settlement has been started within a few years by Mr. Bush and his sons, and other settlers are now coming in. On Apache Creek is a recently established Mexican settlement called Apachita. At Old Fort Tulerosa is a settlement of Americans and Mexicans. Along the road between this and the San Francisco plazas are other settlers, and these latter plazas, three in number, already quite extensive, are rapidly growing Mexican towns, and now contain several hundred inhabitants. A fine cattle-ranch has been taken up by Mr. Patterson, at Cienega, at the western edge of the San Augustin Plain. A few miles north of this is Horse Spring (also taken up) on the road from the Rio Grande to Old Fort Tulerosa. All of these settlements, including Springerville, trade with the towns on the Rio Grande. Although Silver City is much nearer, their roads lead to the Rio Grande but none to Silver City. The utility of one is apparent, but even from the plazas it will be a difficult matter to get a good wagon-road to Silver City.

In proceeding from the plazas to Silver City we still follow down the San Francisco, which, after the Tulerosa joins, is a rapid stream some fifteen feet wide and a foot deep. A dim, little-used, and washed-out road was followed down the cañon some twenty miles until, owing to the narrowing of the cañon, the road is compelled to take the hills on the west side, and, after a rough route of some six miles, returns to the stream at the head of what is called the "Meadows," where, for five or six miles, the stream flows through open meadows, in places a mile or more in width. At the foot of the meadows, in which we found the first settler was just establishing himself, the road again leaves the river and is somewhat rough and hilly for a few miles to Whitewater Creek, where is another embryo settlement. A couple of miles below Whitewater the road finally leaves the stream and crosses the drains from the Mogollon Mountains toward Duck Creek Pass. Entering this a fine slope extends to the Gila River. The road from Duck Creek to Mule Spring is intersected near the pass. We found that little work had been done on the road above Whitewater. With the exceptional cases where it traverses open ground it can scarcely be called a road until four or five miles below Whitewater, from which point, towards Duck Creek, enough work has been done to get tolerably over the bad places. The present route, with a good deal of labor, could be made a passably good wagon-road from where it comes to the stream at the upper end of the meadows, or probably twenty-five miles below San Francisco to the Gila, whence there is a good wagon-road to Silver City by Mangas Springs. The twenty miles of road through the cañon of the San Francisco below the plazas can never be kept in repair owing to the sandy character of the soil and consequent liability to wash. To build a road there would require a large outlay for bridges and grading as well.

Mr. Morley, engineer in charge of survey party for the Atchison, Topeka and Santa Fé Railroad, went over this route from the Tulerosa Pass a short time before we traversed it.

The principal difficulty, then, in building a wagon-road from the San Francisco plazas to Silver City is met in the first 25 miles from the plazas.

There is a fair road from the plazas up Tulerosa Creek, which passes the settlement at Old Fort Tulerosa, and thence, by way of Tulerosa Pass, leads to San Augustin plain, and gives an outlet to the Rio Grande.

The people at the plazas believe a road can be built from the towns, keeping in the foot-hills to the north and west of the stream, and coming upon it at the upper end of the meadows before referred to. In this event, and probably without a great outlay of labor, a mountain-road can be constructed from the plazas until the good part of the route is reached below Whitewater Creek, whence there is a good road to Silver City.

Springerville, Ariz., on the Little Colorado, should be connected with Silver City, New Mexico, by road. The road from Springerville to Bush Valley, being direct, would be utilized as far as the pass of the Escudilla Range, and probably as far as Bush Valley. From this place we tried to find a route by following the drain of the San Francisco and found it impracticable. A more direct route would be through the hills directly south from Bush Valley. It would probably have to pass to the southwest of the San Francisco mesas and reach the San Francisco at the meadows.

Had opportunity permitted I should have gone over this route also; but the drain of the San Francisco was selected as probably the most feasible. It is probable that, whether assisted by the government or not, the people of the country will construct a road somewhere in the vicinity of this indicated route within a few years.

From Duck Creek, instead of following the wagon-road to Silver City by Mangas Springs (known to be good), we took the trail passing by the north of Bear Peak. We crossed the Gila about five miles above Old Fort West, where there is a thriving farming settlement called "Upper Gila." The river above breaks out from a rocky gateway, in sight, in the Diablo Mountain, and here flowing through the open country is a rapid stream about 25 feet wide and 12 or 15 inches deep. From the Gila, until the old saw-mill at the head of Bear Creek and near to Bear Peak was reached, we had a rough trail; thence to Silver City a well-traveled wood road.

On the 30th of October we reached Fort Bayard, and joined the remainder of the party at Apache Tejo two days later. The result of our observations up to this time showed (1) that a good wagon-road already exists from Fest's Ferry by way of Cañada Alamosa, Ojo Caliente, Luera, and Encinosa Springs, and the Burnt Fork, to Saint John's, on the Little Colorado; (2) that a railroad could readily be constructed over or contiguous to this route; (3) that if the course of the Rio Grande were adhered to in passing north from El Paso it might be possible to somewhat shorten the total distance between El Paso and Saint John's (over the way by Fest's) by constructing the desired road by way of the head of the Cuchillo Negro, and thence joining the first in the San Augustin plain; (4) that the vicinity of the Tulerosa Pass offers no good passage to the Little Colorado for either a wagon or rail road; (5) that to connect Springerville with Silver City by direct route will be difficult, and at best it will be a mountain wagon-road; and (6) that between these two routes the country is so broken—there being the Mimbres, the Mogollon, the Diablo, the Tulerosa, and the Escudilla-Datil Mountains—that it is considered impracticable to construct a route in the direction desired, namely, in the northwest and southeast direction, for this direction cuts across these ranges.

The usual observations were made on this trip, a continuous meander line run, topographical notes taken, the measurements being made by odometer. Cistern-barometer observations were made as far as Encinosa Spring; after that, the cistern being out of order, the altitudes depend upon aneroid readings. Adjacent to that portion of our route within the limits of atlas-sheet 84 A, *i. e.* about the San Augustin plain, a number of topographical stations were occupied. From San Francisco Plaza, Eagle Peak was occupied as a main triangulation station on the 23d of October. The principal points sighted were Madalena, San Mateo Cook's and Thomas Peak (of the White Mountains). The three first made complete triangles in connection with Maxson's work of 1877, and Nell's occupancy of Cook's Peak, current year.

### MR. NELL'S PARTY.

During our absence on this trip, Mr. Nell, with his party, had been steadily working in the country proposed. He had surveyed the country between the ridge of the Mimbres and the Rio Grande, from the Cuchillo Negro south to the road from Mesilla to Old Fort Cummings, as well as the vicinity of Cook's Peak, Hot Springs, and Apache Tejo to Fort Bayard. About twenty-five judiciously selected topographical stations tions had been occupied; the courses of the Cuchillo Negro, Arroyo Seco, Animas, Perches, and other streams from the eastern slope of the Mimbres meandered; the Rio Grande gauged at Palomas and Fort Selden, its course meandered as far south as Mesilla; the important roads of the country meandered; the mines at Hillsborough and in Cook's range located; a base-line about 5 miles in length, located at Apache Tejo to connect with the astronomical monument established at Fort Bayard, 10 miles distant, and several of the development stations occupied and monuments built on all. As located by Mr. Nell, the base lay nearly in a north and south direction, the middle point being about one half mile west of the camp at Apache Tejo. It was so laid out as to be as nearly as possible exactly on the line joining two development stations (D and F), so that with the assistance of but two lateral points, the line between D and F, about 26 miles in length, could be determined. This line afforded at once a base for connection with Cook's, Florida, and Bear Peak, points embraced in the main triangulation. The base-line passes over the slightly undulating, grassy plain characteristic of the low lands, extending south toward the Mexican line. Leveling showed the southern station (B) to be 298.5 feet lower than (A). When laid out the line was marked by colored flags, 200 feet apart; two measurements were made with compensated steel tape, at an interval of two weeks, and entirely independent of each other, the extremities of the tape-line being placed on movable boards; the first gave 27,265.968 feet, and the second 27,265.920 feet. The ends of the base were marked by upright poles, 3 to 4 inches in diameter, about 12 feet high. During the months of October and November the country around Fort Bayard was menaced by Indians, and several murders occurred which were attributed to them, and numerous instances of horse-stealing. The vicinity of the Florida Mountains having, on previous occasions, been made a rendezvous by the Indians, was considered dangerous for small parties to enter. Having information from Captain Beyer, the commanding officer at Fort Bayard, that a scouting party would be sent to the Florida and the Hatchet Mountains, I determined to accompany the command, as far as possible, on this trip. Atlas sheet 90 A, a portion of which is cut off on the south by Old Mexico, was surveyed from the eastern slope of the Florida to its western line, and in addition the northern portion of the Hatchet Range, the eastern slope of the Las Animas range, and a strip of country in the eastern part of 89 B. The party left Apache Tejo for this trip on the 5th of November, joined Captain Beyer's command that same evening at Hot Springs, and remained with it until the 15th, when we had reached the Hatchet Mountains. The route of the party was from Apache Tejo to Fort Cummings, over the stage-road. Two days' detention was caused at Fort Cummings by a heavy rain-storm. From this place a route was taken (with a by-road only for a few miles) across the valley of the Mimbres, (here dry) to the Black Rock Tanks at the north end of the Floridas, failing to find lake-water as had been anticipated, in the bed of the Mimbres. Meanders were run along the foot of the slope on either side of the Floridas, and four points in the range occupied. From Las Tinajas, near the south end of the range, we crossed a low flat valley, that has been supposed by many to be the bed of the Mimbres, into the Tres Hermanas, and thence crossed another valley west to Carrizillo Spring, on the old road south from Carrizillo Spring into Mexico. Observations were made at the Mexican boundary monument, four and one-eighth miles south of the spring, so that our work can be connected with that of the boundary survey. From Carrizillo Spring Mr. Nell, with a small party, returned to Apache Tejo over the wagon-road, and, arriving several days before the rest of the party, made the second measurement of the base with the result given above.

From Carrizillo Springs Hatchet Peak was made the objective point for the rest of the party. We proceeded along the main road, and crossed the right angle of the territory of old Mexico, there made by the boundary line, to the east slope of the Hatchet Mountains; thence, after occupying the peak, followed the road to the Eureka mining district, to Carrizillo Spring and to Apache Tejo.

November 23d, the base work being completed, Mr. Nell, with a portion of the party, took route up to the basin of the Mimbres to its head, and afterwards completed the survey of the branches of the Gila within our area. The course of the Gila was followed from the mouth of Agate Creek to about the mouth of Black River, and thence the trail to the Sapillo. From the Sapillo to near Pinos Altos they had a dim trail through the Diablo Mountains, arriving at Fort Bayard December 7. Meantime Mr. Gillette finished the topography about Pinos Altos and Georgetown and intermediate, embracing there the southern slope of Diablo Mountains to the summit, points of which were occupied. A portion of the time I was engaged in obtaining statistics of mining operations in the vicinity. Mr. Lyon started east from Fort Bayard November 25, Mr. Gillette and Mr. Schleicher December 6, and on December 9 Mr. Nell, Mr. Hasson, and myself, the party having been disbanded December 6 to 8, in accordance with your instructions. Much of the minutiæ of our work, including the meteorological work, the routes traversed, the camps made, triangulation and topographical stations occupied, with the instrumental work incident thereto, and the various detours to points of interest, are omitted from this report. It is believed that the field and office records and the completed sheets will best elucidate these details. The survey of a good portion of 84 A, nearly the whole of 84 C, and more than half of the part sheet 90 A was carefully made, in addition to the special trip to the Little Colorado.

### SUMMARY.

The party was in the field 128 days.

The main triangulation stations occupied were as follows, viz:

1. Eagle Peak, near south end Tulerosa Mountains.
2. Cook's Peak, highest point Cook Range, near old Fort Cummings.
3. Florida Peak, highest point Florida Range, near north end range.
4. Hatchet Peak, highest point Hatchet Range, near north end range.
5. Bear Peak, high point about 8 miles north of Silver City.

The base development stations were four in number. Bear Peak and two of these last-named stations were visible from the astronomical monument at Bayard. The proper connection was thus made. In occupying the main stations care was taken to connect with Thompson's work, 1873, under Lieutenant Hoxie, Maxson's work under Lieutenant Morrison, 1877, and current year under Lieutenant Griffin, as also to observe points to the westward with a view to connection with triangulation in Arizona.

In addition to the above, the principal topographical stations (which were also either secondary or tertiary triangulation stations) occupied were as follows:

No. 3. Wooded point, west Shaw's ranch.
No. 6. Belle-view Bluff, near Barenda Creek.
No. 7. Peak near Cuchillo Negro, south of cañon.
No. 8. Peak in forks Cuchillo Negro.
No. 9. Peak near head Cuchillo Negro.
No. 10. Peak connecting divide near head Gila.
No. 11. Peak near head Gila.
No. 12. Peak east slope Mimbres, between Cuchillo Negro and Palomas Creek.
No. 13. Peak east slope Mimbres, near Animas Creek.
No. 14. Animas Peak, near Hillsboro', north.
No. 15. Peak between Animas Peak and Hillsboro', north.
No. 16. Peak east slope Mimbres between Apache and Whitewater Creeks.
No. 18. Peak, main ridge Mimbres near head Whitewater Creek, (cone shaped.)
No. 19. Signal-rock, near Whitewater Creek.
No. 20. Peak, near head Jara Losa Creek.
No. 21. Roblado Peak, near Fort Selden, (north point.)
No. 22. Picacho, opposite Las Cruces, near Rio Grande.
No. 23. Peak, Magdalena Range, near Mason's ranch, south.
No. 24. Peak, Goodsight Range, north of road to Cummings from Slocum.
No. 25. Peak, Cook's Range, south of Cummings's road.

No. 27. Peak near Macho Springs, west.
No. 28. Hurricane Bluff, on divide near road Macho Springs to Brockman's, north.
No. 33. Bluff near Black Rock Tanks, Florida Range.
No. 35. Peak near Las Tinajas (south), Florida Range.
No. 36. Peak near Niggerhead Spring (north), Tres Hermanas Mountains.
No. 37. Peak in range of hills near Luera Spring, east.
No. 39. Peak highest point Horse Mountains, north.
No. 40. Crater near Virgil's ranch, Little Colorado, Arizona.
No. 41. East Peak, group near Horse Spring, south.
No. 42. Round Peak, cone divided between San Augustin plain and Gila.
No. 44. Rancheria Peak, (high), south end Florida ranges.
No. 45. Hill near Carrizillo Spring, south.
No. 46. Cone in group south from Cow Spring, Carrizillo road.
No. 48. La Lacha Peak, highest in Animas Range, near Eureka mining district.
No. 49. Pinos Altos Peak.
No. 50. Cone between Pinos Altos Peak and Bear Peak.
No. 51. Black Peak, highest point Diablo Mountains.
No. 52. Peak at Hanover copper mine, north.
No. 53. Hendrick's Peak, near Magruder's, northeast.
No. 56. Thanksgiving-day Peak, near head Miembres.
No. 57. Peak on continental divide, near head Agate Creek.
No. 58. Bluff at Gila, opposite mouth Agate Creek.
No. 59. Bluff at Gila, opposite mouth Black River.
No. 60. Bluff near trail between Gila and Sapillo, west.

Number 60 was the last station occupied, and number indicates the total of topographical stations, in which is included all of the triangulation stations except three.

| | |
|---|---|
| No. of monuments built | 32 |
| No. of bases measured | 1 |
| No. of azimuths determined | 1 |
| No. of three-point stations | 184 |
| No. of variation needles by observations on Polaris | 40 |
| No. of sextant latitude stations | 34 |
| No. of camps (main and side.) | 154 |
| No. of miles meandered | 2,509 |
| No. of meander stations | 2,273 |
| No. of miles traversed but not meandered | 990 |
| No. of cistern-barometer stations | 186 |
| No. of aneroid-barometer stations | 1,221 |
| No. of mining localities visited | 11 |
| No. of hot or mineral springs visited | 7 |
| Rio Grande River gauged, times | 2 |

## DESCRIPTION.

The north and south tier of atlas-sheets 84 A, 84 C, and 90 A, embraces the country immediately west of the Rio Grande, in Southwestern New Mexico, except a small area north and west of El Paso, from the thirty-fourth degree of latitude (a little south of Socorro on the Rio Grande) to the Mexican line, and extends west to the meridian of Silver City.

The Rio Grande River, cutting into the two northern sheets, leaves a small part of each on its eastern side.

This country may well be remarked for the diversity of its natural features, and, except for the sandy belt immediately along the Rio Grande and the lowest parts of the San Augustin plain, for an almost entire absence of barren soil.

Its resources in grazing land and fine timber are excellent; its mineral resources varied and valuable. Agriculture, in common with our Western territory where irrigation is required, is confined to the immediate vicinity of the streams. The part that can be used for planting is very limited, since where water is plentiful ground available for irrigation is scarce, and in the plain country flowing streams are lacking.

The country is naturally divided as follows: Into the San Augustin plain; the San Mateo and Mimbres Ranges, and the country west of this latter and south of the San Augustin plain, comprising the mountain region; the Rio Grande slope; the broken region extending east from Cook's Range to the river and embracing the Goodsight and Magdalena mountains; while south of these and the mountain region a generally open plain extends south to the Mexican line.

The San Augustin plain, opening to the northeast, and to which access may be had by roads leaving the Rio Grande at the mouth of the Puerco, at Alamillo, at Socorro, at Fort Craig, and by the Cañada Alamosa, lies partly in the northern portion. It will be recalled that the Tulerosa Pass connects this plain with the San Francisco River to the southwest, and the Mangos Pass gives passage to the Little Colorado.

The greater part of this plain is well adapted for grazing; good water is to be found only in the springs in the foot-hills that surround it, and the supply, though limited, is yet sufficient to support numbers of cattle; Monica, Encinosa, and Horse Springs, and the Cienega at Patterson's each give a copious supply; Pueblo and Luera, now weak, can be much improved by digging. Of the first, all were occupied at our coming except Encinosa, Pueblo, and Luera. A flat of low, marshy ground, very alkaline, exists where the waters of the Cienega reach the drainage line of the valley. I found it impracticable to cross this with animals.

The San Mateo and Mimbres Ranges, running generally parallel to the Rio Grande, leave an open country some twenty miles across, sloping to the river from their foot-hills. Peaks of the San Mateo were occupied by Lieut. Morrison's party in 1877, and that region, together with the Rio Grande slope as far south as to include the Cuchillo Negro, will be found described in his report of that season's work.

The Rio Grande slope continues south from the Cuchillo Negro until it merges into "the broken region" south of Mule Spring, where is a pass that separates the Mimbres and Cook's Ranges. Numerous streams have their rise in the Mimbres, and flow eastwardly toward the river; scarcely any of their waters reach it except during the rainy seasons. The ground is of sedimentary formation. A characteristic of the larger streams, when clear of the mountains, is their channels, which are deep cuts, with almost vertical sides a hundred or more feet deep and several hundred yards across, presenting insuperable obstructions to road building athwart them. The most important are Palomas, Arroyo Seco, Animas, Perchas, and Apache. At the mouth of the Palomas is a Mexican town of the same name. The recently established mining town of Hillsboro is on the Perchas, in the foot-hills. Except this, only a few settlers are found away from the river; a little mining camp is on the Animas, about ten miles above its mouth, while near the road leading from Hillsboro to Mule Spring *four settlers* are established.

The foot-hills of the Mimbres are rocky and steep; a slide seems to have occurred, which has left a valley between the main ridge and the foot-hills, through which latter the streams cut in narrow rocky cañons. Good grazing is to be had, which has heretofore been principally devoted to sheep.

The vicinity of the Rio Grande presents little of interest; the Caballo range, bare and rocky, forms a barrier along the east side, so that there is no road crossing the river between Fest's and the ford, 10 miles above Selden. On the west side a road follows the bank, and much of the freight for Fort Bayard, Silver City, &c., passes this way, crossing from the east side at Fest's ferry, and leaving the river at Cottonwood ranch; thence to Macho Spring the road passes through an undulating country, sandy near the river. From Macho Spring the road goes to Mule Spring, where the right-hand fork may be taken to Georgetown via Brockman's Mill, or the left, which leads via Hot Spring to Fort Bayard or Silver City. This is the shortest practicable route to these points from Socorro. From a little below the mouth of the Animas a road leads to Hillsboro, and thence, as before mentioned, to Macho Spring, where it joins the freight road; south of this road the vicinity of the river is sandy, few persons living there. Where the river was gauged at Palomas, September 19, 1878, the width is 465 feet, and the greatest depth only 2.1 feet. At Fort Selden the width is 368 feet and the greatest depth (October 3, 1878) but 2.2 feet. It is remarkable for its shallowness; but more than this is the fact that within a couple of years the river-bed between Mesilla and Fort Bliss has been found for a distance absolutely without running water. This perhaps better than anything else will indicate the sandy soil through which it has to struggle, but of course a good portion of the water of the already shallow river is used in the irrigation of land about the large towns of Mesilla and Las Cruces.

From Santa Barbara below Cottonwood Ranch a road leads past Mason's Ranch to old Fort Cummings, but the distance between Mason's and Cummings is without water.

At Mesilla is the junction of the government telegraph-lines from Santa Fé, from Southern Arizona, and from Texas via Fort Bliss. Stage and mail routes follow the same directions. The western route, which is the southern mail-route to the Pacific coast, leads to Fort Bayard and Silver City; thence across Southern Arizona. Between Mesilla and the Mimbres River it crosses directly the Magdalena, the Goodsight, and the Cook's Ranges, which are nearly parallel.

The Magdalena and Goodsight are low, dry ridges, and the country about them and intervening from the Rio Grande to Cook's Range is dry and uninteresting. Near the river it is sandy; west the grass is good, but there is no timber, and water is exceedingly scarce. Slocum's Station, or Mason's, on the road from Mesilla, between Santa Barbara and old Fort Cummings, affords the only permanent water. Macho and Mule Springs belong to the drainage at the south end of the Mimbres Mountains. Cook's Range, so named from the prominent peak which forms the central figure, is but an extension to the south of the ridge of the Mimbres. Old Fort Cummings, where there is a splendid spring, is at the east base of the range. It has been abandoned for several years. Where the road crosses the summit a mound of earth marks the burial-place of a party of emigrants, who were surrounded and killed by Indians some years since. Mines have been located on the summit of the ridge about 2 miles to the north of the peak. The drainage from the range is west and south into the basin of the Mimbres.

The mountain region, which will be taken from the San Augustin plain south to include the Santa Rita Hills and Lone Mountain, is interesting and important.

The Gila and Mimbres Rivers head in it. The first receives its tributaries from the Mimbres Mountains on the east and the Mogollon on the west, and flows southwestwardly, cutting in a deep, narrow gorge the Diablo Mountains, which, a little north of Fort Bayard, trend westwardly athwart its course and inclose the headwaters of the river in a mountain basin, which is troughed by deep precipitous cañons in as many different places as there are flowing streams. The Continental divide northward from Bear Peak, near Silver City, makes a double curve. First bending to the northeast, it separates the Gila from the Mimbres River, and with the Mimbres Mountains merges into a single ridge of wooded hills that lie west of Ojo Caliente. From a northward direction there it changes to the west and passes in a great curve around by the south and west of the San Augustin plain. A divide to the Mogollon Mountains incloses the headwaters of the Gila, while at Tulerosa Pass and at Mangas Pass we find the main divide in its course to the north.

A grassy, rolling country with dry drains characterizes the northern portion of the Gila basin; then heavily-wooded country begins, with water-courses and deep cañons. Except a couple of ranches on the Sapillo there are no settlers on the Gila or its tributaries above the gorge of the Diablo Mountains. The Mimbres River heads about latitude 33° 10′ and flows nearly directly south, sinking at average water about 4½ miles below the town of Mimbres, on the Mesilla and Bayard road. At the crossing of this road (November 5) the river was about 12 feet wide and 6 inches deep. A number of settlers are located along the river to McKnight's Ranch, about 30 miles above this road.

In the southern part of these mountains is a tract of country about 20 miles square, of which Fort Bayard is nearly the geographical center, which embraces, besides Silver City, Georgetown, Pinos Altos, Lone Mountain, Santa Rita, and Upper Mimbres, at all of which except Silver City mining interests predominate. Extensive gold, silver, iron, and copper mines have been opened.

Of the plains lying between this country and the Mexican line, I desire to call attention to the large extent of fine grazing land now lying idle there, and to express, as I believe, the well-founded hope that advancing population will one day bring to the surface the underlying water, which will, in connection with the fresh-water lakes to be found in many places after rain, afford means for maintaining there large herds of cattle.

The generally level or slightly rolling country is separated from the Rio Grande by the Portrillo Mountains (a low range of hills); and is broken by the Florida and Tres Hermanas Mountains and several low groups in the western and southwestern part.

The drain of the Mimbres River, generally represented on maps as being west of the Floridas and between that range and the Tres Hermanas, passes instead by the north and east of the Floridas toward Pigeon Lake in old Mexico.

After two days' heavy rain, when, in many places on the level, the ground was too soft to travel over, we crossed the bed of this river in passing from Fort Cummings to the north of the Floridas, and found it quite dry, and somewhat indistinct. Cistern barometer measurements showed this crossing to be about 50 feet lower than the lowest point in the flat between the Floridas and the Tres Hermanas. From the summit of Florida peak, too, it is quite easy to trace the dark line of mesquite bushes that grow most plentifully in the dry bed of the river, and show it passing to the north of the Floridas. The Floridas, a short sharp ridge rising some 2,000 feet above the plain, form a prominent land-mark. There is no timber on these and very little wood; water, too, is found in very limited quantities.

The trail which was made by Captain Beyer's command will undoubtedly remain distinct for years. Following it from old Fort Cummings, the first water will be found at the Black Rock Tanks; next a seeping spring (dry during a part of the year); then about the middle of the range a spring about one-half mile west of the direct trail is to be found flowing over white rocks, and where there is at least a little water throughout the year. Again, in the cañon from the southern to the southeastern high point of the range two living springs are near its head, and near where it opens into its first valley running water will be found, in the bed rocks, in the wet season, and water in rock cavities at other times, though I do not think the supply would warrant permanent settlement. These waters are on the eastern slope. No permanent water is known on the west side.

These contiguous sharp peaks to the southeast, though much lower than the Floridas, readily mark the Tres Hermanas. West of the peaks is a group of hills of limited extent, whose foot-hills on the south barely reach the Mexican line. As in the Floridas, a few stunted trees only are growing. The trail leads to the Niggerhead Spring, in the midst of the hills, in a cañon draining to the south, the only permanent water known in the group. In several other places water may be found in holes after rain.

West of the Rio Grande our routes into old Mexico lead south from the vicinity of Fort Bayard. At Cow Spring, some 50 miles north of the line, the road converges from from the Mesilla road at the town of Mimbres and Hot Springs, and from Fort Bayard and Silver City, where there is a custom-house officer. A little south of Cow Spring the road forks; that to the left, and which has been long in use and much traveled, passes by Carrizillo Spring. After rain, water may be found near this road in two places between Cow Spring and Carrizillo. South from the latter spring the road soon passes into old Mexico.

The right-hand road has been established within a few years, and since the opening of the silver mines at Eureka, south of the mining camp, it crosses at an acute angle the international line where the latter runs north and south, and joins with the Carrizillo road at El ojo de los Mosquitos, in old Mexico.

The grade and bed of both these roads is good, and there is little difference in distance, wood and water on both being equally scarce.

### HOT SPRINGS.

Adjacent to the Silver City and Mesilla road, where the mountain slopes merge into the plains, is found *the* Hot Spring of Southwestern New Mexico. It is 21 miles from Fort Bayard by the military road. There is also a warm spring at Apache Tejo, and a third one near the first (a little west), and a fourth in the hills east of and near the Mimbres River, some 10 miles south of Upper Mimbres. The temperature of Hot Spring is very high. The water rises in a circular opening at the summit of a small knoll, which has been formed by mineral deposited from the water when it overflowed about the spring. The same formation is now going on in the troughs which conduct the water from the spring. A neat house is kept, with bath-rooms. The curative properties of the water are said to be great. The temperature of the spring at Apache Tejo is 89°, there is a copious flow of water, and when cooled the water is excellent drinking. The temperature of the other two springs is respectively nearly 150° and 120°. Both are copious.

During the ensuing summer the Atchison, Topeka and Santa Fé Railroad will be completed to Las Vegas, New Mexico. From that place to Silver City the distance by freight road, via Anton Chico, Ponta del Agua, to the Rio Grande at La Parida; thence by Socorro, Fests and Cottonwoods, and Macho and Hot Springs, is 357 miles. From Las Vegas via Anton Chico, Tigeras, Albuquerque, Socorro, &c., the distance is 30 miles greater. To Georgetown by going up the Mimbres River the distance is 343 miles, or 14 miles less than to Silver City. The distance from Albuquerque to Georgetown by this route is 246 miles; by the North Star route (leaving the Rio Grande at Lower Sabinal) the distance to Georgetown is 230 miles, a difference of 16 miles in favor of the latter route. This, however, is very hilly, and at present impassible from washouts; and without great additional expense it can never be made even a passable freight road.

### MINING INFORMATION.

The working of the mines at Silver City, Pinos Altos, Lone Mountain, Georgetown, and Hillsboro was examined as far as practicable, and the results are submitted on the forms furnished by the office. Some general and special information otherwise collected is given here. As before stated, these towns (except Hillsboro) lie about Fort Bayard as a center.

A general view of this mining region shows a central ridge of granite rock extending from Pinos Altos in a southeasterly direction through Fort Bayard, and containing gold in seams, the direction of these being generally perpendicular to the outcrop.

Near Fort Bayard the gold is found in slate in very narrow quartz seams, as in the Stuart and San José mines. At Pinos Altos in the granite rock the vein matter is more decomposed, and the veins are several feet thick; along the west of this is found slate with overlying limestone, in which the extension of the gold-bearing veins shows silver predominating, as shown in the Langston mine at Pinos Altos and some workings at Central City.

Proceeding further to the west the slate comes to the surface at Lone Mountain and Silver City, and silver is found principally as chloride, in pockets. At the former place the formation is faulty, the slate is found nearly perpendicular, and over it limestone with silver in pockets, while a little to the south of this well-defined veins are found in limestone. The '76 mine in Chloride District (Silver City), owned by Mr. Bremen, affords a most interesting study.

The slate dips to the east (inclined about 75°). The deposit is found between two beds of slate, with pockets occurring at intervals, and a large amount of metal has been taken out. Little method has been observed in the mining, but tunnels have been run in every direction between the beds, sometimes with good results and sometimes without. That this body of ore is connected with a deeper deposit, and perhaps a vein, seems probable, and the present effort of the mine-owners is to develop that by shafts, and at the same time to prove or disprove the theory that similar deposits will be found between beds of slate below, as has been said to exist in similar cases.

Returning again to the east of the granite rock, the adjacent slate carries gold; next, limestone is found. An outcrop in this has been followed to some extent, but not sufficiently to develop a vein. Cubic galena and other forms of lead, with probably some silver, was taken out. Next, to the east of this, occur extensive deposits of copper in carbonate and black oxide, but also extensively red oxide as nearly pure copper, the vein-rock being apparently a soft feldspathic rock. Near Santa Rita an abundance of iron ore occurs with the copper, and alone. The old Hanover copper mine develops the belt at the north, and the Santa Rita at the south.

To the east, again, a ridge of limestone hills intervene to Georgetown, where the abrupt break to the Mimbres River uncovers the slate at the present Georgetown silver mines. The dip of the slate is just the reverse of the strata at Silver City. This superficial veiw of this section is given to invite attention to the apparently symmetrical arrangement of the silver deposits on the flanks with reference to the other metals in the center.

A geological description of this heterogeneous and faulty district (principally in a valley of erosion and almost surrounded by eruptive rock) must be left to the careful scrutiny of a geologist.

## GOLD MINING.

Other than the workings at Pinos Altos and Hillsboro, on the Rio Grande slope of the Mimbres Mountains, little is being done at present. A shaft about 40 feet deep has been sunk at Central City, where the surface-rock is granite, on a ledge which promised gold on the surface. The present indications point to silver, but the vein is not yet considered developed. The old San Jadi mine and the Stuart mine, about 1¼ miles east of Bayard, are not being worked at present, the seams having been found too small to pay well. The San José has been extensively worked, and is said to have paid well in places. At the Stuart mine an interesting experiment is being conducted by Mr. R. E. Humphreys, who is working the old dump by what is claimed as a new process.

The vein of this mine is well exposed in the shaft, and varies from a mere seam to a thickness of three inches. The ore in the dump has been exposed for several years. It is taken by Mr. Humphreys, and worked in ordinary arrastras; the object of his process being to save the *fine gold*, a well-known source of wastage. This is accomplished, as the work goes at present, by attaching to the revolving upright a double arm, from which copper tubes about one-half inch in diameter and about an inch apart extend downward and dip into the tube; the tubes being coated with mercury, and coming in contact with almost every particle of the fluid, the fine gold is amalgamated, and sinks. Twenty to $25 per ton is claimed to be taken from one dump that was scarcely considered worth milling.

Iti s perhaps unfortunate that ore direct from the mine has not been selected for this experiment, as the disintegrating effect of the atmosphere on the dump has undoubtedly done much to facilitate the separation of the gold (a well-known fact).

In November but one ordinary arrastra was in use. Important details of the process have not been arranged, and cannot therefore be given.

## SILVER MINING.

The Eureka silver-mining district, in which the first location was made in May, 1877, lies twenty-two miles north of crossing of the Mexican line, near the west road leading south from Cow Spring, and is about 75 miles from Silver City.

The district was worked with enterprise for a little more than a year. In October, 1878, the only residents were Mexicans—in all about twenty persons.

A small Mexican smelter is erected at the spring, three miles south of the camp. Ore worth about $200 per ton was being taken from the Bonanza Hill near the surface, where the country rock is limestone.

About a mile to the north of this is the King mine and the Tilden lode, parallel veins, and which have been laid bare to varying depth for several hundred feet along the surface, and several shafts have been sunk. Selected ore (about two tons) taken from the King mine yielded at the rate of $286 per ton.

The ores are copper, silver glance, and chloride. Assays have been made giving several thousand dollars to the ton. Other specimens of glance are almost barren. The rich ore, as is almost universal throughout this region, occurs in bunches.

A well has been sunk in an arroyo near the mines, and several adobe houses have been built; of which but one, however, appeared to be occupied.

In Silver City the only mill running was working on tailings, which paid better than the first working of the ores—a fact well worthy of notice. A lead recently opened by J. H. Miller & Co., about five miles northeast of Fort Bayard, contains principally lead; about forty tons of ore have been taken out, but not yet worked.

There is galena and a very friable black, yellow, and brown ore. Specimens of the black have been found to fuse readily in the heat of an ordinary fire.

Orr's mine, located near the summit of Cooke's Range, a few miles to the north of the peak, contains also a very large percentage of lead, and has been used as a flux at the mills. Here is also found an extensive deposit of fluor-spar.

Near the head of Whitewater Creek, on the west slope of the Mogollon Range, deposits of copper (silver) glance have been discovered.

Mr. McEvers's Ranch, some 20 miles south of Hillsboro, is another locality of silver. Work done there, however, during the summer did not give good results.

There are probably 5,000 acres of cultivable land along the Mimbres from Mc Knight's Ranch south, and fine crops of potatoes are raised, with grain. A scarcity of water is sometimes felt in May and June, which precede the rainy season, belonging to the months of July, August, and September. This land, together with the valley of the Upper Gila (so called), near old Fort West, cultivated to its full extent, will more than furnish staples for the adjoining country. Grass is abundant and need not be cultivated; hay can be cut in any desired quantity from the open plain. Brockman's grist-mill, on the Mimbres, is the only one in this vicinity. A market for lumber would utilize the fine timber so abundant in the Burro and Diablo Mountains and the mountain basins of the Gila and Mimbres Rivers.

The advance eastward of the Southern Pacific Railroad, and the contemplated junction of the Atchison, Topeka and Santa Fé with it, will, it is hoped, soon open this country to railway communication, with great increase of prosperity.

### COPPER MINING.

A belt of country lying a few miles to the east of Fort Bayard, and between that place and Georgetown, is rich in copper. Iron is found adjacent to the copper and also with it.

The oldest mines are those at Santa Rita, at present owned by Messrs. Caffee, Moffat, and Dudley & Gill, of Denver, Colo.

I am indebted to Mr. Wm. M. Pierson, agent, for the following brief historical sketch:

The deposits were known to the Indians and surface worked by them. In 1800 they made them known to Colonel Corasco, of the garrison of Hunnas, in Old Mexico. Colonel Corasco sold the mines to Manuel Elga, a merchant of Chihuahua, for $338,000, which amount was borrowed for the purpose from Don Palacio Garia, a banker of the city of Mexico. Elga contracted with the Mexican Government to take all the production of the mines at the rate of 55 cents per pound, and repaid the amount borrowed in three years. In 1828 the Mexican Government (then a republic) issued an order compelling all Castilians to leave the country. Elga rented the mines and went to Spain. McKnight & Cusier were the rentees until 1835, then Sweet & Lacost, of San Antonio, Texas, until 1862, when they were expelled by Federal troops. The mines remained idle from that time until 1873, when they were purchased by the present owners from the heirs of Manuel Elga.

### WORKINGS.

The ore was first found in masses near the surface, and was quarried rather than mined. Two of these excavations remain, one about 150 feet square and another 100 feet square and 30 feet deep. Afterwards a shaft was sunk nearly between the two. Up to 1862 it had been sunk 250 feet, and had two series of driftings, one at 125 feet and the second at 250 feet. Each series covers an area of about 500 square feet, and consists of a system of galleries intersecting each other at right angles and distant apart from 15 to 20 feet.

In 1873 work was recommenced. Six months were required to exhaust the water from the mine. A fifteen-horse-power engine was used. This has since been replaced by one of double the capacity, and the latter is now at the works. After exhausting the water the shaft was sunk 50 feet, but without drifting. After working about a year the present company ceased work, owing to the low price of copper and the difficulty of transporting it from Santa Rita to market. The mine has since rapidly filled with water. The present owners have also erected a fine Swansea furnace at a cost of $10,000. The dimensions of the furnace are 11 by 20 feet, and has a capacity to reduce ten tons in twenty-four hours. It has not been used for three years, but remains in good condition.

A controversy prevails as to the quantity of land belonging to the grant. Eleven leagues are claimed.

The deposits of copper cover about one square mile of territory, and probably extend in a continuous belt about two miles to the north along the east slope of the Bayard Basin to the site of the (old) Hanover copper mine.

About half a mile to the north of the Santa Rita shaft are the Chino and Yosemite copper mines, claimed by the Santa Rita Company, but they are held and have been worked by other parties. They were extensively worked by Messrs. Magruder & Fest, but work ceased in 1876 owing to the depreciation of copper.

The Hanover mine above mentioned has not been worked for a number of years. The superintendent was killed by Indians, and the settlement abandoned in consequence.

Near the Santa Rita shaft Mr. Pierson has opened three new prospects. In the first a shaft 6 by 10 feet has been sunk 25 feet on a deposit of mineral. Sixty-five tons have been taken out, which assays show to contain about 70 per cent. of copper and 30 per cent. of iron. In the second there is developed a couple of sedimentary deposits of copper, one 11 feet wide by 2 thick, the other 9 feet wide by 15 inches thick. In the third, surface croppings about 30 feet square containing red oxide of copper, but principally the carbonate, malachite, and azurite in white porphyry, so called.

Red oxide, malachite, azurite, and copper combined with iron (as oxide) constitute the principal forms in which the copper occurs in all these mines, though large masses of nearly pure copper (native) have been found. The native copper is principally found in continuous narrow seams, in a white rock that seems to be nearly pure feldspar. Beautiful specimens of these leaves are taken from the rock when it is broken open. The carbonates occur disseminated through a more friable but somewhat similar country rock. The deposits generally are irregular and do not occur in veins.

Iron is found abundantly over an area about one mile wide by three in length, intersecting the copper ore.

Very respectfully,

ROGERS BIRNIE, JR.,
*Lieutenant of Ordnance, Executive Officer.*

Capt. GEO. M. WHEELER,
*Corps of Engineers, in charge.*

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## APPENDIX F.

### REPORT OF LIEUTENANT M. M. MACOMB, FOURTH ARTILLERY, IN CHARGE OF PARTY NO. 2 CALIFORNIA SECTION, FIELD SEASONS OF 1878 AND 1879.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
*Washington, D. C., September 20, 1879.*

SIR: I have the honor to submit the following report of the operations of the parties of the California section under my charge during the field seasons of 1878–'79.

### EXECUTIVE REPORT—SEASON OF 1878.

Leaving Washington July 21, I proceeded direct to Carson, Nev., where I arrived July 28th. Lieutenant Symons had already nearly completed the organization of my party in connection with that of his own, and it was ready for the field August 1, 1878, with the following *personnel*: Lieutenant M. M. Macomb, Fourth Artillery, executive officer and field astronomer; J. C. Spiller, topographer; J. H. Morgan, meteorologist; J. B. Callahan, odometer recorder; Charles W. Howell, chief packer; H. Medlicott and N. F. Dow, assistant packers; Alexis Bochet, cook.

August 2 the party was joined by R. Raycraft, man of all work, who was employed temporarily, so that the party could be divided into two effective sections, one for main triangulation and topography, the other for meander work and secondary triangulation, as will be subsequently explained. Total, including myself, nine men.

Our transportation consisted of twelve pack and nine riding mules, with one bell-mare. Total, twenty-two animals.

The instrumental outfit was the same as that usually allowed a party organized for triangulation and topography, and needs no special mention.

The work assigned the party was as follows: First, to carry the triangulation of the previous season far enough westward to connect with that carried out from the Panamint base, as well as joining with the scheme carried eastward as far as Austin, Nev., in 1876, by Lieutenant Birnie's party; then moving westward, to carry the scheme as far down into the foot-hills of the Sierras as possible, so as to close with the work proposed to be carried out from Fresno, Cal.

The area to be worked up topographically lay directly south of that done by my party the previous season, and included the southern part of atlas 56 B, and as much of atlas-sheet 56 D as possible. See Progress Map of 1879.

The season being already far advanced it became a matter of the utmost importance to complete as soon as possible the work in the high mountains, so as to avoid disaster from the autumnal storms. Hence the following plan was adopted:

First. To move southward to Highland Peak (occupied by me in 1877), for the purpose of selecting and sighting points to be brought into our season's triangulation.

Second. To separate into two parties; one, under Mr. Spiller, to carry the triangulation to the south, as previously stated, forming a net of triangles between the crest of the Sierras and the high peaks of the Wassuck and White Mountains. The other, under my personal supervision, to finish the topography in the southern third of atlas-sheet 56 B, the two parties to meet at Bridgeport, Mono County, California, about September 1.

Third. Leaving Bridgeport during the first part of September to strike into atlas-sheet 56 D, carrying the triangulation entirely across it and down into the foot-hills of the western slope of the Sierras.

By arrangement with Lieutenant Randolph, quartermaster of the survey, supplies for two months were to meet us at Bridgeport, for one month at Mariposa, and for another at Sonora, California, if needed.

Accordingly, August 1, the party left Carson, passing south through the Carson Valley, and camped August 3 on Dixie Creek, near Highland Peak. The route was so chosen as to permit the survey of roads and trails not meandered the previous season.

Highland Peak was successfully occupied on the 4th, and on the next day we divided our forces as follows: The side party for triangulation consisted of Mr. Spiller in charge; Mr. Morgan, meteorologist, with Medlicott and Raycraft as packers, the transportation being four riding and four pack animals. As this party would have to make long and rapid marches, only those articles absolutely necessary were taken, the great bulk of the baggage remaining with the main party. Each section took a month's rations. It is worthy of remark that the above organization is all that could be desired for a quickly-moving party, specially destined to to carry on triangulation over a rough mountain country during a field season of four or five months. The number of men, four, is fully large enough to do what is required, and yet could hardly be diminished for any length of time without throwing too much upon individual members. The triangulator, having an intelligent assistant, who records and takes the necessary barometric readings, is enabled to devote his whole time and attention to his sketches and observations, and can in a given period accomplish the largest possible amount of good, accurate work. With two reliable men to cook, pack, and look after the animals, the triangulator and his assistant have opportunities to leave the ordinary route and study the country by side reconnaissances. Moreover, one man may be always left in camp while the other assists on the peak in carrying the instrument, building the monument, &c. A party thus organized could work rapidly and economically, without being overworked, and could collect the best data obtainable with a ten-second transit and a mountain barometer.

The triangulation party being fairly started, I moved up Wolf Creek and over its divide into Hermit Valley on the Mokelumne. From Hermit Valley the Big Tree road was surveyed to Blood's toll-house, connecting here with a meander run by me the previous season from the Big Tree Grove. After occupying a couple of topographical stations, the Big Tree road was followed to Big Meadow Creek and here we turned to the right, running a meander over a stock road as far as the mining village of West Point near the west edge of our area. From this point we traveled northward until the Antelope and Pine Grove turnpike was reached, which was surveyed to its junction with the Amador road at Antelope Springs. The Amador road was now surveyed up to Tragedy Springs, connecting here with the work of 1877. Returning to Antelope Spring the meander was continued to Volcano and thence back to West Point. Going south from this village we passed through Railroad Flat, and then moved southeastwardly over a rough mountain road until the Big Tree road was intersected near Dunbar's sawmill, now abandoned.

The roads and trails in the vicinity of the Calaveras and South Groves of big trees were surveyed, after which the party proceeded to Sonora, via Murphy's, Douglas Flat Vallecito and Columbia, all mining villages. From Sonora the Mono road was followed to Strawberry Flat on the Stanislaus and beyond as far as Niagara Creek, thus giving a complete survey of this celebrated route between the western foot-hills and the Aurora and Bodie mining districts. Owing to the recent rich developments at Bodie everything looked cheerful and busy along the route, and the through line of stages put on during the summer was doing a thriving business.

The time between August 20 and September 2 was spent in finishing the topography of the block of country lying south of the Sonora and Mono road and north of the old "Relief" Trail. Castle Rock, Grizzly Peak, and four other points were occupied for topography and the Relief Trail meandered from Strawberry to Leavitt's across the mountains.

September 2, found me in Bridgeport, but, as the other party was not yet in, I occupied for topography Buckeye Peak and a point to the north, both prominent points in the montains west of Bridgeport.

On my return I found that the other party had arrived after a remarkably successful trip, a very satisfactory set of observations having been obtained.

After our separation on August 4, Mr. Spiller proceeded by the most direct route to Cory's Peak, and completed his work from this station August 10. This peak is one of the points in the scheme of triangulation being carried across the interior by the Coast Survey. Their station was not made on the summit, but at a more convenient spot to one side.

The next point visited was McBride's Peak, the most prominent northern point of the White Mountain range, and after that White Mountain Peak, the highest point visited during the season. A high point of the Sierra Nevada, near Mount Abbott, was also selected and occupied, and finally, September 2, the mission of the side party was completed by the occupation of Mount Dana, north of the well-known Bloody Cañon trail.

On meeting at Bridgeport we decided that it would be necessary to reoccupy Sonora Peak. This was done by Mr. Spiller September 10. Meantime I made a trip from Bridgeport down the East Walker to Hoye's store, on the West Walker, and returned by the cañon of that stream, surveying the new road then being built from Coleville to the Mono road. September 12 we left Bridgeport and prepared to take up the mountain work and topography of Sheet 56 D. We ascended the valley of Virginia Creek and camped near its head, for the purpose of occupying what is locally called Castle Peak, but which we named Dunderberg, after the mines of that name upon its northerly slope, desiring to avoid duplicating the name which we had already given to the castellated volcanic mass north of the Central Pacific Railroad near Summit Station.

Owing to bad weather we were detained in the neighborhood of this peak until September 19 before we finally completed our observations. During this time snow fell nearly every day. Previously we had been remarkably fortunate as to weather, and had been able to work continuously, but now it seemed as if the elements had determined to combine against us and prevent our finishing our work. From this time on I determined to make every effort to get our main triangulation at least well done, even at the sacrifice of the topography. Our next important point was Mount Conness, on which we completed our observations September 24. From our camp at the base of Mount Conness we moved to the Tuolumne Meadows, *en route* to Mount Lyell. This we succeeded in ascending after a hard climb, only to find all our trouble rendered fruitless by the clouds and chilling mists which hung about the summit, absolutely precluding the taking of any angles. Not being able to spare any time waiting for better weather, we returned to the Tuolumne Meadows and completed our meander work and made one more topographical station.

On the 29th it snowed nearly all day, but the 30th was clear enough for topographical work. Taking advantage of this we made two stations and moved camp to the Cathedral Meadow and the next day occupied the highest one of the Cathedral Peaks, and another.

October 2 and 3 were spent upon Cloud Rest and a couple of minor points, and October 25 we entered the Yosemite Valley. Mr. Spiller at once took up the survey of the existing roads and trails, while I prepared for a trip to Mount Lyell, the weather now being favorable for its occupation. After a hard day's work interrupted greatly by heavy winds, I at last succeeded in getting the necessary angles and on the following day, by a forced march of 35 miles, returned to the valley. We now prepared to make a complete circuit of the valley by the old Mono trail on either side, but on the 14th, in camp on the head of Cascade Creek, were overtaken by a heavy snow-storm, which gave us 14 inches of snow during the day and night. This made it impossible to continue our trip, as every blade of grass was covered so as to prevent our finding feed for our animals. We were therefore obliged to return to the valley, but, as it was absolutely necessary that Mounts Hoffman, Clark, and Merced should be occupied, Mr. Spiller and myself started out with two men and a few pack animals and worked our way through the snow, which was melting rapidly, and succeeded in completing our task on the 26th.

Tower Peak being now the only high point remaining to be occupied, I thought it best to attempt it at once. A conversation with an old hunter in the Yosemite led me to believe that the peak might be reached by following up some one of the long ridges running northeasterly from the Hetch-Hetchy Valley. Accordingly a main camp was established here and several attempts made to find a practicable route. The country turned out more broken and intricate than I expected, and the threatening nature of the weather, combined with the time of year, made it unwise to attempt the topography of this desolate region, so that I determined to withdraw and take up the triangulation in the western part of our area. On our return from the Hetch-Hetchy, Wade's Peak was occupied for triangulation and topography, the survey of the Coulterville road completed from Hazel Green to the Valley, and that of the Mariposa road finished as far as Cold Spring Station.

From Cold Spring I sent on to Mariposa and replenished my stock of rations, Devil's Peak being occupied meantime for triangulation. I now moved to the southeast corner of our area where Chiquito Peak was occupied, as well as Deadwood, near Fresno Flat. This peak lies just south of the southern line of our area, and was occupied to assist in connecting with the work from the Fresno base. All the meander work which could be done in the limited time at our disposal was looked to, but it was held subservient to the triangulation.

The 28th of November, Thanksgiving, was spent in Mariposa. Letters of instruction received here from you ordered me to disband in Sacramento not later than the 17th of December. From this time on, therefore, the work was hurried as much as possible, Green Mountain, our most southerly point, being occupied December 2, and Schultz Mountain December 6, the party returning to Mariposa on the 7th. From this town we proceeded north through Bear Valley to Coulterville, and thence down Moccasin Creek to Culbertson's on the Big Oak Flat road.

Moccasin Peak, near here, was visited on the 10th, but we were unable to take a complete set of angles, owing to heavy timber and misty weather. On arriving at Sonora the following day letters from Sacramento ordered the party in at once, and accordingly the 13th found us at Milton on the Stockton & Copperopolis Railroad, whence the party was transported by rail to Sacramento, and there disbanded on the 14th of December.

The party was in the field 135 days and made in all 100 camps. The following list shows numerically the principal observations made:

| | |
|---|---|
| Number of points occupied as primary triangulation stations | 22 |
| Number of points occupied as secondary triangulation stations | 14 |
| Number of points occupied as three-point triangulation stations | 163 |
| Number of meander stations | 2,975 |
| Number of miles meandered | 899 |
| Number of miles traveled without meander | 1,493 |
| Number of cistern-barometer stations | 216 |
| Number of aneroid-barometer stations | 858 |
| Highest altitude reached (approximate) feet.. | 14,100 |
| Lowest altitude reached (approximate) feet.. | 171 |

During the first part of the season the weather was generally favorable and the party worked very rapidly, our travel from August 5 to September 5 being over 1,000 miles.

I desire to express my thanks to all the members of the party for faithful and cheerful performance of their respective duties during the entire season, and would especially commend Mr. Medlicott for his skill and daring in climbing mountain peaks.

## EXECUTIVE REPORT—SEASON OF 1879.

The field season this year was unusually short, it not being possible to carry on the field work after June 30, owing to lack of funds. It was possible, however, even in the brief time allotted, to collect a large number of important data relating to the topography in atlas-sheet 56 D, as well as to complete the angular measurement of the triangles having apices at Blue Mountain and Moccasin Peak, two important primary stations selected in 1878. All the work to be done was subsidiary to that assigned my party in 1878 and lay in the same area.

Under your orders I left Washington May 5, with Mr. Maxson as assistant, and reached Sacramento May 12. All the members of the party joined here and the organization was completed, so that the entire party, men, animals, and *matériel* could be sent on the 14th to Oakdale, terminus of the southern branch of the Stockton and Copperopolis Railroad, and the most convenient point from which to start our season's work.

Arriving here late on the evening of May 15 we were obliged to spend the 16th in determining the "per mile" of the odometer, adjusting instruments, fitting aparejos, making up the packs, in short taking all the precautions necessary to enable the work to be carried from the start to the finish without unnecessary delays. The organization of the party was as follows: Lieutenant M. M. Macomb, Fourth Artillery, executive officer; F. O. Maxson, topographer; Corporal F. J. Hill, Fourteenth Infantry, odometer recorder; B. P. French and Charles W. Howell, principal packers; Henry Sayre, assistant packer, and Delancy Willson, cook; total, seven men.

The transportation consisted of seven riding and nine pack animals, with one bell mare and one extra mule; total, eighteen animals. We carried rations for forty-five days.

Owing to the large amount of work to be done and our limited time the party was so organized as to admit of being split into two sections, the plan of operations being as follows:

The party was to work together for about eight days surveying the roads in the plains and getting the topography of the foothills in the western part of the area, the presence of snow making it unwise to advance at once into the high country to the east.

Next, to divide our forces, Mr. Maxson with three men was to finish the important topography left undone the previous season; while I, with the remaining two, was to complete the triangulation by the occupation of Moccasin and Blue Peaks, and, if the absence of snow permitted, Tower Peak in the main Sierra, obtaining at the same time all the topographical data possible.

Accordingly, on the 17th of May the field work was begun by running a line to Roberts' Ferry on the Tuolumne, just where it leaves the western edge of our area. The ensuing week was occupied in meandering the roads between the Tuolumne on the north and Bear Creek on the south and studying the topography of the adjacent foothills. Mr. Maxson and myself generally ran independent lines, one taking the odometer, the other working by time and three-point stations. The villages of Snelling and La Grange, Hornitos, Indian Gulch, Chinese Camp, and Jacksonville were visited and all the important thoroughfares surveyed, leaving only those which we could easily complete on our home trip. The 25th of May found us encamped at Marshall's Flat near Moccasin Peak. This point Mr. Maxson and I visited together and from here I pointed out to him our principal stations of the previous season, with which he was to connect his work, and explained to him as well as I could the character of the country he was about to enter. That evening I furnished him with a letter of instructions laying down the camps and marches for each day up to June 19th, when we were to meet in Sonora, where I was to receive definite orders as to time of stopping work. It was of course understood that Mr. Maxson was to use his own good judgment in varying the plan laid down for him, whenever swollen streams, deep snow, or other unforseen contingencies rendered it advisable.

Accordingly, May 26th Mr. Maxson and party broke camp at Marshall's Flat and I saw no more of them until our rendezvous at Sonora.

The first work done was a survey by three-point stations of the ridge running southeasterly from Moccasin Peak to the Coulterville road, camp being made at Haigh's, two miles above Coulterville. From here the route was by the old Boneyard road to Black's; thence by trail to Hennessey's bridge on the Merced; then to Hite's Cove, and the southward to Fresno Flat, which was reached May 30. From this village the route was over the northern part of the newly constructed "Madera and Yosemite Turnpike," which was carefully surveyed. The next march was to Chiquito Meadows, and the Chiquito Joaquin via the old Long Valley trail, which was surveyed to the eastern edge of our area. Several days were spent in studying the topography in this vicinity, the party returning to Clark's on the 6th of June.

The well-known old trail from Clark's to the Yosemite was then surveyed, and that valley itself entered June 9 by the Glacier Point trail. Two days were spent in carefully determining by theodolite the altitudes and relative locations of all the prominent points about the valley, and then, until June 15, the time was occupied in gathering topographical details north of the Yosemite.

The trail down the Merced Cañon to Hennessey's was then surveyed and a line run over an Indian trail to Hazel Green, on the Big Oak Flat road. The survey of this thoroughfare to Culbertson's, on Moccasin Creek, was then made, connecting here with our previous line from Jacksonville, on the Tuolumne. From this village a line was run, via Kincaid Flat, to Sonora, which was reached June 19, thus completing the plan of operations assigned Mr. Maxson's party in May.

While this work was in progress I proceeded with the triangulation and topography from Moccasin Peak, where I was delayed two days on account of bad weather and heavy timber which had to be cleared off.

I then started for Blue Mountain, running time meanders over roads not previously surveyed, and completed the triangulation from this point June 4.

The high Sierra appeared so snowy that I knew it would be impossible to reach the summit of Tower Peak for perhaps a month to come, but as there was still considerable topography in that direction to be studied, I hoped to be able to gather some important features before our time was up. I therefore returned to Sonora and followed the Mono road as far as Bradford's sawmill, where I turned off to the right and followed a stock trail, which brought us out in Cherry Valley, through which runs Cherry Creek, a large stream draining into the Tuolumne from the north.

I was delayed here a couple of days by rainy weather, but on the 12th started up the ridge on the east side of the valley, hoping to be able to reach some of the minor points southwest of Tower Peak, if not the peak itself. I was accompanied by Mr. Thomas Richardson, who has a sheep range in Cherry Valley and vicinity, and who is perfectly familiar with the rugged country south of the Relief trail. After we had reached an altitude of about 8,000 feet above sea level, the snow became so deep as to effectually bar our progress. Seeing that it would be folly to attempt anything further in this direction, I determined to spend the few days still at my disposal in studying the topography in the neighborhood of Lake Eleanor and the Hetch-Hetchy Valley. This work occupied me until the 18th of June, when I started for Sonora, reaching that town the following day, and there met the other section of the party under Mr. Maxson.

Instructions received here from you informed me that it would not be necessary to reach Milton, our disbanding point, before the 27th of June. This gave us another week in our area, and this time was profitably employed in meandering roads and gathering topographical details to the south and west of Sonora and in making a secondary triangulation station on the southern and highest point of the Bear Mountain Range, about six miles northeast of Copperopolis.

This practically completing our field-work, the party was marched to Milton on the 27th, and the following day transported by rail to Sacramento and there disbanded. Thus ended a short but profitable field season, during which time all the members of the party displayed the warmest interest in the work. Messrs. French, Howell, Sayre, and Willson more than sustained their previous good reputation for steadiness and hard work, and Corporal Hill, Fourteenth Infantry, was all that could be desired as odometer recorder. Too much praise cannot be accorded Mr. Maxson for his unflagging energy and practical knowledge of his work, which, continued, enabled him to collect a vast amount of map material in the short time allowed us.

We were in the field forty-two days, during which time thirty-two main camps were made. An inspection of the following numerical list of principal observations taken will show that our average daily travel was over 34 miles.

| | |
|---|---|
| Number of main and secondary triangulation stations | 3 |
| Number of three-point stations | 154 |
| Number of meander stations | 2,325 |
| Number of variations determined | 36 |
| Number of cistern barometer stations | 48 |
| Number of aneroid barometer stations | 659 |
| Number of miles meandered | 833 |
| Number of miles traveled without meander | 599 |
| Total miles traveled | 1,432 |

### TRIANGULATION.

The main points on which our triangulation depends, with their altitudes as far as determined, are:

Highland, 10,956 feet, main point of Silver Mountains near Silver Mountain City, California.

Cory's, 11,326 feet, main point of the Wassuck Mountains west of Walker Lake, Nevada.

McBride, 13,443 feet, most northern peak of White Mountains east of Owen's River, California.

White Mountain Peak, 14,200 + feet, highest peak of White Mountains east of Owen's River, California.

Morgan's Peak, ——— feet, high point of the Sierras near Mount Abbott, California.

Dana, ——— feet, high point north of the Bloody Cañon trail.

Sonora, 11,479 feet, northeast of the Sonora Pass, California, on Sonora and Moon road.

Conness, 12,518 feet, prominent granite peak northwest of Mount Dana.

Lyell, 13,191 feet, culminating point of the divide between the Merced, Tuolumne, and San Joaquin Basins.

Hoffman, 10,872 feet, at head of Yosemite Creek.

Clark, 11,295 feet, most northerly peak of the Merced group.

Devils', 6,910 feet, north of Cold Spring Station, Mariposa and Yosemite road.

Chiquito, 8,136 feet, on ridge west of Chiquito Joaquin Creek.

Deadwood, 4,451 feet, timbered point near Fresno Flat, California.

Green, 1,352 feet.

Schultz, 2,275 feet, west of Cathey's Valley.

Moccasin, 3,003 feet, prominent timbered point in ridge west of Moccasin Creek.

Blue, 6,076 feet, timbered point on ridge between South and Middle Forks, Mokelumne River.

All these points, with the exception of Blue, were occupied during the field season of 1878. Besides the above points, a number of others were occupied as secondary stations, so that all the topographical work of the area visited is based on an excellent scheme of triangulation. From the main and secondary stations an immense number of points were located by cross-sights. Sights were also taken to prominent points of the Coast Range, such as Mount Diablo, Mount Hamilton, &c., so that their positions can be computed. The area included between the exterior lines of our main triangulation of 1878 is, roughly, 7,159 square miles, and the computations showed a remarkable degree of accuracy in the observations.

This work, it is to be remembered, was done in addition to a large amount of topography, and too much credit cannot be given to Mr. Spiller for his energy and the interest manifested by him in the work. Had it not been for his knowledge of the previous work done and his excellent judgment in selecting points to be occupied, the work could not have been successfully completed within the allotted time.

### DESCRIPTIVE REPORT.

The area examined for mapping during the seasons of 1878–'79 includes the southern part of atlas sheet 56 B and all of 56 D, and is immediately south of the work of 1877. It embraces that portion of the main crest of the Sierra extending from the Sonora Pass to Mount Lyell, also the drainage basins of the Stanislaus, Tuolumne, Merced, and part of the San Joaquin Rivers, as well as part of Fresno, Chowchilla, Mariposa, and Bear Creeks. The area presents an immense variety of topographical features, from the rugged and intricate country adjacent the high Sierra to the flat and monotonous expanse of the great San Joaquin Valley.

Two of the most remarkable features—unparalleled, perhaps, in their way—are the deep gorges known as the Yosemite and Hetch-Hetchy Valleys, of which special mention is made further on.

The great timber belt of California runs directly across the area examined, which contains no less than six groves of that giant of American vegetation, the *Sequoia gigantea*. These are the Calaveras and Great South or Stanislaus Groves, those of Mariposa and Fresno, besides two of minor importance on the Big Oak Flat and Coulterville roads, respectively. As we descend from the belt of heavy timber we find large agricultural areas devoted to the cultivation of fruit and some grain in the foot-hills, and almost entirely to the latter in the broad expanse of the great valley. The land not taken up for agricultural purposes is used for grazing during the fall and early spring, after which great numbers of sheep and cattle find an agreeable change of feed in the meadows of the high mountain country.

The foot-hill section has for years been the scene of mining industry which has developed numerous towns, the better known being Sonora, Coulterville, and Mariposa. Although these places have perhaps seen their best days there is still in the foot-hills a vast amount of wealth undeveloped and a number of mines and mills in successful operation. Among these latter is the Hite's Cove mine, examined and reported on by Mr Maxson.

### YOSEMITE VALLEY.

This wonderful locality has already been so minutely and accurately described in the various guide-books now published as to render any lengthy account superfluous. The gap that we have filled topographically is comprised in careful surveys of the three great roads into this valley and of the three important trails leading out of it, namely, the Eagle Point trail, the Glacier Point trail, and the Nevada Falls trail, none of which have ever been accurately mapped. Careful barometric determinations have been made for the altitude of the valley, and also a series of observations were taken to obtain reliable altitudes of all the points of interest. Owing to the fact that the final computations have not yet been completed it is not possible to give a full list of these.

As the observations were taken with especial care it is hoped that they will finally settle all disputed points.

### THE HETCH-HETCHY VALLEY.

This valley is worthy of especial remark as being perhaps the most remarkable feature of the great Tuolumne Cañon. To those who have time to leave the usual routes of tourist-travel it would well be worth a visit. It may be reached either from Hardin's or Hodgdon's at Bronson's Meadow on the Oak Flat and Yosemite road by very good trails. The route pursued by us was from Bronson's Meadows. The following table gives the distances and altitudes along the trail:

| Station. | Miles. | Altitude above sea. | Remarks. |
|---|---|---|---|
| | | *Feet.* | |
| Hodgdon's | 0.00 | 4,506 | Stage station, Big Oak Flat road. |
| Crossing, south fork Tuolumne | 1.18 | 4,163 | Ford. |
| Wade's Meadows | 2.05 | 4,567 | Also called by Meadows now. |
| Crossing, middle fork Tuolumne | 2.00 | 4,158 | Ford. |
| Hog Ranch | 3.00 | 4,550 | Ranch and Meadows. |
| The Cañon | 2.86 | 4,849 | Small cattle ranch. |
| Cabin, Hetch-Hetchy Valley | 5.21 | 3,489 | At foot of trail, west end of valley. |

| | Miles. |
|---|---|
| Hodgdon's to Hetch-Hetchy | 16.30 |
| Total—Oak Flat to Hetch-Hetchy via Hodgdon's | 44.22 |
| Total—Barnard's Hotel, Yosemite, to Hetch-Hetchy | 37.65 |

The trail from the cañon on is rough and steep, but perfectly practicable for horses and pack-animals. Our barometric observations give 3,469 feet as the altitude of the middle of the valley above the sea, or 382 feet below the Yosemite. The total length of the valley is only about 3½ miles.

While it cannot be compared with the Yosemite in size or in grandeur, it perhaps more nearly resembles that valley than any other known locality, and has at least sufficient beauty and individuality to produce an ineffaceable impression on the observer.

The two most striking features are the great dome on the south side of the valley, rising some 2,500 feet above the river, and the magnificent falls opposite. These falls which pour over the north wall of the valley at about its middle are in an angle formed by a great buttress just to the west, which recalls the El Capitan of the Yosemite. While this water-fall is similar in position and effect to the Yosemite it has not the same sheer plunge which is the remarkable feature of that fall. But to make up for this it has a much larger drainage basin which contains some quite sizeable lakes which act as reservoirs, so that in volume and constancy at least it is far superior. In spring and early autumn there is a second fall which is quite noticeable, as it pours over the northern wall farther to the west. The lip of this is about 1,750 feet above the Tuolumne, that of the main fall being 2,000 feet. The high granite bluffs east of the falls rise about 3,090 feet above the valley.

Besides the first trail described, two others leave the valley north of the river, one at either end of the valley; that at the west end passes by a steep zigzag route up a mass of *debris* coming down into the cañon from a glacial moraine above; a ledge of rock on this trail, about 1,060 feet above the river, affords an excellent general view of the valley; the other, leading out at the east end of the valley to a meadow known as "Rancheria" and to numerous other meadows used as sheep ranges. The former trail leads to McGill's meadows, and lake Eleanor, thence to Cherry Valley and on to the Sonora and Mono road at Bradford's saw-mill. After getting out of the cañon on this route, by following a trail forking abruptly to the right, we reach in a few miles a very pretty sheet of water on Hetch-Hetchy Creek, called Lake Vernon by the sheep-owners, on whose range it is; this is the principal reservoir of the Hetch-Hetchy Fall.

After leaving the Lake Eleanor trail we commence to ascend and pass over a very well-marked moraine, its summit where we cross being about 2,760 feet above the Hetch-Hetchy.

One interesting point which we find in the Hetch-Hetchy, and not in the Yosemite, is abundant evidence of glacial action. The glacial polish is very plain on the granite rocks forming the bed of the valley east of the dome, while some hundreds of feet above, the rocks show well-marked horizontal grooves. Fine examples of the same agency occur in the basin of Hetch-Hetchy Falls Creek, and in those of the streams emptying into the east end of the valley from the northeast. This valley was first brought to public notice by the California State geological survey, and is described and mapped by Professor Whitney in his "Yosemite Guide Book."

### CHERRY VALLEY AND LAKE ELEANOR.

Cherry Creek drains a large area south of the Relief trail and, in fact, is the largest stream coming into the Tuolumne from the north. Cherry Valley is a large meadow or flat on this creek, its general direction being about north and south. It is nearly three miles in length and varies from a quarter to three-quarters of a mile in breadth. It contains a large extent of fine grass and is claimed by Mr. Thomas Richardson, of Oakdale, and is by him used as a sheep range. When we visited it in the middle of June we found that even the presence of large flocks of sheep had failed to drive off the numerous bands of deer, which the snow still kept out of the high mountains. An alkaline pond about a third of a mile from Richardson's cabin was the nightly resort of numbers of deer. This valley has also for years been the resort of grizzly and cinnamon bear, and several of the latter were seen during our short stay. Two fine specimens had been killed shortly before our arrival. Our barometric observations give 4,615 feet as the altitude of this valley above sea-level. This locality is easily reached by turning off from the Mono road just above Bradford's saw-mill, about five miles beyond Northrup's. There is a rough wagon road as far as Hull Meadows, now Lord's, and from here on a very fair trail much used by sheep and cattle owners. By fording Cherry Creek and crossing a low gap in the ridge east of it we come to Lake Eleanor, a very pretty sheet of water about a mile in length and from half to three-quarters of a mile broad. It is fed by three streams, two coming in at the north, and one at the south end. This lake is claimed by parties residing in Columbia and Sonora, and was by them stocked with trout in the fall of 1877. It now contains a large number of fine fish. By passing around the south end of the lake and fording the creek a trail will be found about half a mile above the ford, which turns up the ridge to the right. This runs to McGill's meadows, and thence to the Hetch-Hetchy Valley, as mentioned under that head. Our observations made the lake 4,630 feet above the sea.

### THE RELIEF TRAIL FROM STRAWBERRY TO LEAVITT'S.

This trail is interesting as being one of the old emigrant trails over the Sierra Nevada. It was spoken of as a possible route for a wagon-road when the Sonora and Mono road was projected, but was rejected as too rough, a better route having been found along the middle fork of the Stanislaus. The accompanying table gives the distances and altitudes along this trail.

| Stations. | Miles between stations. | Miles from Strawberry. | Altitude above sea. | Remarks. |
|---|---|---|---|---|
| | | | *Feet.* | |
| Strawberry | ........ | ...... | 5,238 | Stage station Sonora and Mono road. |
| Burst Rock | 9.86 | 9.86 | 9,157 | |
| Trail to Cooper's milk ranch | 3.75 | 13.61 | ........ | Cooper's, 3.08 miles by left-hand trail. |
| Meadow, head of west fork Relief Creek. | 3.09 | 16.70 | ........ | On divide between Stanislaus and Tuolumne drainage. |
| Near junction east and west forks | 3.20 | 19.90 | 7,892 | Trail crosses west fork. |
| Meadow on east fork Relief Creek | 4.53 | 24.43 | 8,816 | Wood, water, and grass. |
| Divide between east fork and Summit Valley. | 1.70 | 26.13 | 9,617 | Divide between Stanislaus and Tuolumne. |
| Divide between Summit Valley and fork west Walker River. | 2.81 | 28.94 | 9,805 | |
| Foot of lake | 8.07 | 37.01 | 8,183 | Lake about one-half mile long. |
| Round lakes | 3.08 | 40.09 | 7,309 | Two small lakes. |
| Head of Leavitt's meadow | 1.15 | 41.24 | ........ | |
| Leavitt's | 1.47 | 42.71 | ........ | Horse ranch and stage station, Mono road. |

### ROUTES OF COMMUNICATION, TABLES OF DISTANCES, ETC.

The main routes examined by us in 1878–'79 were the Big Tree road, from Silver Mountain City to Murphy's, the Sonora and Mono road, running from Sonora to Bridgeport, and the Bodie mining district; also the three great wagon-roads connecting the foot-hill towns with the Yosemite Valley, and known, respectively, as the Big Oak Flat, the Coulterville, and the Mariposa roads; also that portion of the new route to the Yosemite from Fresno Flat to Clark's or Big Tree station, on the Mariposa road.

The western portion of this route, between Madera, on the Southern Pacific Railroad, and Fresno Flat, was not examined, as it lay entirely without our area. Tables of distances and altitudes on all these important roads have been compiled to accompany your report of this year.

### CONCLUSION.

A great deal of interesting country in and about the Yosemite and High Sierra is not described, because this has been so well done by Professor Whitney and Mr. J. M. Hutchings in their respective guide-books. Thanks are due to the latter gentleman for kindness shown the party while in the Yosemite. I wish also to tender my thanks to Mr. Conway and other proprietors of toll trails in that valley for their courtesy in extending us the free use of their trails while we were obliged to use them in the course of our work.

Respectfully submitted.

M. M. MACOMB,
*First Lieutenant Fourth Artillery.*

Capt. GEO. M. WHEELER, *in charge.*

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## APPENDIX G.

### REPORT OF LIEUTENANT H. H. LUDLOW, THIRD ARTILLERY, IN CHARGE OF PARTY NO. 3, UTAH SECTION, FIELD SEASON OF 1878.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF 100TH MERIDIAN.
*Washington, D. C., April* 4, 1879.

SIR: I have the honor to report on the operations of party No. 3, Utah section, during the field season of 1878, as follows:

The party known as special triangulation and topographical party consisted of H. H. Ludlow, second lieutenant Third Artillery, executive officer; Francis Klett, topographer and assistant; William L. Bailey, meteorological observer and recorder; John S. Stewart, packer; and M. G. Brenholtz, private Company E, Fourteenth Infantry.

Your instructions were to complete certain triangulation work near Austin, Nev.; and then to proceed to Fresno, Cal., where a base line was to be located, measured, and developed.

The personnel of the party was completed at Ogden, Utah, July 24, 1878. On July 29 the party took train for Battle Mountain, Nev.; thence traveling by pack to Austin.

We reached Battle Mountain about 1 p. m., July 31, and made preparation for a speedy departure.

August 1 found the party under way, and it reached Austin about 5 p. m. on the 5th, having rested Sunday, August 4, at Vaughan's Ranch. A stay of ten days in our camp at Rucker Corral, Austin, Nev., gave opportunity for connecting the astronomical monument with the summit of Mount Prometheus by measuring and developing a short auxilliary base, and for occupying, besides the astronomical monument and the ends of the base, three auxiliary stations; also to replace the base-line monuments in Reese River Valley, and to reoccupy Mount Prometheus, as directed by your letter of instructions. It remained to occupy Geneva, Bunker Hill, Poston, Birchim's, Emigrant, and the bases in Reese River Valley. To do this a trip of fifteen days had been planned and the preparations were nearly ready when a serious accident delayed the party about a week. The camp was situated on the main street of Austin, in the immediate vicinity of frame buildings. It was no more exposed than the majority of the buildings on that street which follows the bed of a dry ravine. It was presumably a safe place to camp, and would, no doubt, have been quite secure in any ordinary storm, protected as it was by a strong stockade fence. But it proved to be just the reverse in one of those sudden deluges of water termed "cloud bursts."

About 4 p. m., August 15, a dark, black-looking cloud came up from the southwest. A light sprinkle soon increased to a heavy shower, accompanied by hail. Soon the water began to run in the middle of the street, and gradually increased to a rushing torrent of about 2 feet mid-depth and 20 feet breadth. Presently the backwater began to come into the yard in which the camp was; but no danger of loss was apprehended as the storm seemed to have subsided. But suddenly, and without warning, a wave about 2 feet higher than the water below it, came down the ravine with a rush. It dashed a wood-pile against the fence corner and tore away a portion, carrying off at the same time nearly the whole outfit of the party. Five days sufficed to make a thorough search for missing articles, some of which were found imbedded in mud over two miles from camp, and to get fairly started repairing the recovered aparejos, preparatory to moving. In the mean while Lieutenant Randolph arrived from Ogden, and brought a complete set of meteorological instruments to replace those carried away. After consultation, it was decided to send Mr. Klett with J. S. Stewart, the packer, to Battle Mountain, there to refit the entire pack outfit, while I, with the rest of the party, should go down the Toyabe Range by wagon to finish the Nevada work. Mr. Klett left Austin August 21, with six mules, taking all the damaged aparejos. He reached Battle Mountain after three days forced marching, and the work of repair went on. The rest of the party started the same day (August 21). On the 22d a severe wind blew the cotton cloth off the base monuments in the Reese River Valley. Fortunately it was promptly reported, and they were repaired the next day.

The party moved (August 25) to Kingston (camp 2) for the occupation of Bunker Hill, which was accomplished on the 26th.

The next camp was in Ophir Cañon in the heart of the deserted town of Toyabe City. One man only lived there, and he only two or three days in the week.

The ascent of a low peak near the summit of the pass (August 28) permitted a view of Mount Poston, about 12 miles distant. I decided to cross to the head of Reese River and attempt Poston from that direction. Starting at 1 p. m. we reached the valley and the nearest ranch about dark. A side trip of two days accomplished the occupation of Poston.

August 31, camp was moved to the mouth of Underdown Cañon (camp 5), where September 1 and 2 were lost from unfavorable weather, the ascent of Birchim's being made on the 3d; after which the party returned to Austin, occupying *en route* Emigrant and the ends of the base with as little delay as possible.

One day at Austin sufficed to replace lost mule-shoes and to collect all property left there. Aparejos had been sent down by Mr. Klett, and on September 9 the party started for Battle Mountain, which was reached at 8 p. m. September 11.

The 12th and 13th witnessed an examination of the repaired outfit. All surplus stores were boxed and shipped to Ogden. Whatever was to go with the party was likewise prepared for transportation by rail, and at 7 a. m., September 14, the party started for California.

On reaching Fresno six days were there consumed in selecting a base line, in making and putting up monuments at ends of base, in gathering information, and in arranging stores for shipment.

The base monuments were in shape triangular pyramids, about 30 feet high, the upper 22 feet being covered with white cotton cloth. The sides of the base were about 15 feet, the greatest width of cloth about 11 feet. A space of 4 feet in width, 9 feet from the top, was left bare, which rendered the monuments more easily recognizable by the appearance of the dark line across each. The posts were set 3 feet in the ground. The base line was located some 5 miles east of Fresno, because of a very thick haze, which obscured not only the distant mountains, but even the nearest foot-hills, the latter being visible during my stay of six days only one day.

Leaving Fresno September 27, the party traveled by the ordinary wagon-road to Centerville, and went into camp on King's River, about 2 miles from the latter place.

Fowler Mountain, a foot-hill about 1,000 feet higher than the river bottom, was occupied, and an attempt was made September 30 on Squaw Valley Mountain, but it was found to be heavily wooded, and, after camping near it, September 29 the party moved back to King's River, making camp about 10 miles higher up than before. Here was occupied one of the highest and sharpest of the near foot-hills, called on the Whitney map Tohoetumne, but misnamed Hazleton on the record I left there. It is at the point where King's River emerges from the foot-hills.

The next camp was at Toll House, which was reached by traveling along the lower foot-hills until the Fresno road was found; thence along it. There is a planing-mill at this point, and nearly all the lumber for Fresno and Centerville comes through this place. Burrows Mountain was occupied in this neighborhood.

The party then moved to Behring's store, some seven miles nearer the high Sierras, in order to procure an Indian guide.

Bald Rock was occupied October 10, and the party moved toward Mount Goddard, following Mr. Dusey's wagon track as far as his cabin on Dinkey Creek, thence taking the sheep trail as indicated by our guide.

The party camped on the evening of October 12 near the base of Lookout Mountain, which was occupied for observation the next day. An incomplete sketch was made and a few angles taken, but all points which had been occupied were hidden by the clouds below but near us. This was the highest point occupied in California by the party, the aneroid indicating 10,000 feet above the sea.

It was planned to occupy a point called Woodchuck Peak, October 14, but this was rendered impossible by a snow-storm; and the party was started back, traveling all day in the storm, and reaching Mr. Dusey's at dark. The greatest depth of snow on even ground was 8 inches. The rigging and aparejos were so soaked that the ropes were unmanageable, and a day was taken to get into traveling order.

Burrows, Hazleton (Tohoetumne), and Fowler were occupied on the return trip, and in addition, Morrow and Squaw Valley were taken among the foot-hills, all of which occupied the party until November 1.

The party being south of King's River, traveled through Ash Spring toward Mount Silliman. A point was occupied November 7 and 8 supposed to be the Bald Mountain on Whitney's map, but it does not correspond. Here the lateness and inclemency of the season caused me to stop work in the mountains. Returning to the base line, "Stokes Mountain," a foot-hill on the county line, was occupied November 11, and the party camped at North Base November 13.

The stores at Fresno went to camp November 16. On the 17th the preliminary measurement of the base line began. The line was ranged out by stakes, every hundred feet accurately aligned. It was November 22 when this had been accomplished. Then followed the measurement proper.

Comparisons were made before going to work and on our return from the line with the standard rods of the coast survey, which rods are 5 feet long at known temperatures marked upon the rods. Two of these had been furnished the party.

A platform about 52 feet long and 1 foot wide was erected. Two steel knife-edges were prepared and screwed on this platform at an approximate distance of 50 feet, the edges being at such a height that the exposed ends of the coast survey rods would just pass over them without touching. The rods were applied along a straight line drawn on the platform. The end of the first rod was carefully sighted even with a knife-edge. The second rod was then applied along the line, and contact carefully made with the one already in position. The first rod was carefully removed and placed in like manner beyond the second and so on, until on the fifth application of the second rod its exposed end projected slightly beyond the second knife-edge. A square wooden block placed on the platform was moved into contact with the projecting end of the rod, which was then removed and the distance from the knife-edge to the block was measured by a 3-inch steel ruler subdivided into hundredths of an inch. The sighting in of the first rod and the reading of the distance to the block were both performed by the same person. The temperature was then read and recorded, together with the measured difference. This operation was then repeated, Mr. Klett exchanging places with me and making the adjustment and the reading the second time. This was likewise recorded, with the temperature. The results were then compared, and if differing more than .03 inch, both operations were repeated.

Having thus obtained the data for the accurate determination of the distance between the knife-edges, the steel tape was stretched. Mr. Klett held the rear end of the tape with the notch at the first knife-edge. An assistant stretched the tape at the forward end until the spring was properly extended, while I, as soon as notified of the adjustment of the rear end, superintended the stretching and measured the difference. This was recorded with the temperature and the operation repeated, Mr. Klett and myself changing places. As soon as his reading had been recorded with its temperature the two were compared and if they showed unreasonable discrepancy, both were repeated. In these comparisons and in the measurement, no change was made in the compensating apparatus, it being set at 60° F.

Before commencing the measurement two iron pins were centered under the monuments. Three wooden stools were made about 3 feet high with soft wood tops, end grain, 4 inches square. From the center of each a plumb-bob hung for centering them on the line, and on their tops a pencil line was drawn to be placed parallel to the line to be measured. A wire was stretched in lengths of 600 feet along the stakes already in line under the immediate supervision of Mr. Klett and myself. The first stool was carefully centered over the starting pin and an ordinary pin driven in its top directly over the iron pin. The tape was roughly stretched to give the approximate distance; the second stool was placed accurately over the wire by means of its plumb-bob and the line on its top brought as nearly as practicable in the same vertical plane with the wire. The tape was then carefully stretched. Mr. Klett adjusted the rear end at its notch; Mr. Bailey carried the forward end; and when properly stretched, I drove an ordinary pin in the forward notch along the pencil line on the stool. The tape was then brought forward, the third stool placed in position, and the measurement continued by bringing up the first stool. I placed all the stools and drove all the pins on the direct measurement.

On the reverse measurement Mr. Klett and I exchanged duties. I took his place the first day, after which the adjustment of the rear end was intrusted to Mr. Bailey, while I held myself in readiness to occupy north base, which was accomplished December 5. The base was leveled December 7 and 8, the distance between rod stations being varied according to the nature of the ground.

South base was partially occupied December 6, and completed December 8, while Messrs. Klett and Bailey were at work with the level.

The astronomical monument was occupied December 9, after the mules had been shipped to Sacramento, Cal., in charge of Stewart and Brenholtz.

I left Fresno December 9 by the night train and arrived in Sacramento December 10, according to instructions, and the labors of the party ended.

The following are some of the results of the season's labors:

| | |
|---|---|
| Main bases measured | 1 |
| Auxiliary bases measured | 1 |
| Triangulation stations occupied | 18 |
| Sights taken | 1,694 |
| Miles marched | 682 |
| Camps made | 41 |
| Cistern-barometer stations | 47 |

In conclusion, let me thank the members of the party for their hearty co-operation. Mr. Klett was invaluable for his many excellent suggestions, especially with reference to the measurement of the base. Mr. Bailey was most remarkable for his zeal and for his care in performing all duties well.

Respectfully submitted.

H. H. LUDLOW,
*Second Lieutenant, Third Artillery.*

Lieut. GEORGE M. WHEELER,
*Corps of Engineers, in charge.*

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## APPENDIX H.

### REPORT OF A SPECIAL ASTRONOMICAL PARTY AT OGDEN, UTAH, SEASON OF 1878, BY T. H. SAFFORD, PH. D., ASSISTANT.

WILLIAMSTOWN, MASS., *May* 7, 1879.

SIR: I have the honor to report my doings at Ogden during the field season of 1878. I left Williamstown on July 12, 1878, for Ogden, via Washington. On July 13 I met

Miles Rock, esq., at Philadelphia, and made arrangements with him for the simultaneous observations to be made by us for the longitudes of stations in New Mexico and Texas. I arrived at Washington July 15, and there made the necessary arrangements with Lieut. S. E. Tillman regarding instruments and other appurtenances of astronomical work.

On July 23 I arrived at Ogden and took charge of the observatory, where I found a transit instrument and chronometers. Observations were made for time on nearly every night for three months, or until October 20. Signals were exchanged on the following dates:

July 25, 26, 27, with Professor Newcomb, U. S. N., at Separation, Wyo.
July 27, 28, 29, with Professor Harkness, U. S. N., at Creston, Wyo.
August 12, 19, 21, 26, 28, with John H. Clark, esq., at Walla Walla, Wyo.
September 5, 17, 20, 21, 22, with Mr. Clark, at The Dalles, Oreg.
October 5, 6, 7, 8, 10, with Mr. Clark, at Fresno, Cal.
September 7, 8, 10, 11, 12, with Miles Rock, esq., at Fort Bliss, Tex.
September 26, 27, 30, October 1, 3, with Mr. Rock, at Fort Bayard, N. Mex.

The telegraphic lines employed were in bad order in the sections beyond the railways, so that for Mr. Rock's stations we were compelled to have recourse, in part, to the longer line via San Francisco rather than to the shorter line via Denver.

The condition of things was such that I invariably observed, when weather permitted, before the time assigned for signals, as I never knew whether the line would be ready for use or not until the telegraph operator, Mr. Henry O. Pratt, came to the observatory at the stipulated time. Mr. Pratt was very skillful and faithful. I was assisted, in copying and various mechanical arrangements while observing, by Sergeant Knight, of the Fourteenth Infantry, and on alternate nights by Mr. H. S. Wallace.

On two nights, October 19 and 20, I observed with Mr. Clark for personal equations. I should also have done this on some of the earlier evenings of my stay in Ogden, in July, but Mr. Clark was not of the opinion that his observation then would be normal.

The time observations on signal nights were completely reduced in the form adopted for this survey, and transferred in that condition to Lieut. B. H. Randolph, A. A. Q. M., of the survey, when I left the field. To this gentleman I am indebted for many favors during the campaign. I left Ogden October 21, and reached home November 1.

I am, sir, very faithfully, yours,

T. H. SAFFORD.

Capt. G. M. WHEELER,
*United States Engineers.*

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## APPENDIX I.

### REPORT OF A SPECIAL ASTRONOMICAL PARTY OPERATING IN CALIFORNIA, OREGON, AND WASHINGTON TERRITORY, BY JOHN H. CLARK, ASTRONOMICAL ASSISTANT.

NOBLE, ILL., *April* 30, 1879.

SIR: I have the honor to submit herewith the following notes respecting the astronomical stations occupied by me during the field season of 1878, together with certain details respecting the work:

### ASTRONOMICAL STATION AT WALLA WALLA, WASHINGTON TERRITORY, 1878.

#### *Geographical position.*

The pier, of cemented brick, from which the observations were made for the determination astronomically of this station, is situated in block No. 9, known as Jail Square, 57 feet from the center of Fifth street, and 211 feet in a straight line to a street monument in the center of Main and Fifth street. (See plat herewith.) The location was objectionable on account of dust, smoke, jar, and noise, but was unavoidable. There was no other place where the pier would probably be protected and at the same time afford the necessary telegraphic facilities. In erecting the pier the magnetic needle variation 20½° east was used. The transit, however, showed it to be largely out of the prime vertical. The unreliability of the needle in this instance is due doubtless to the components of the soil, which is here constituted largely of bowlders charged with magnetic iron.

### *Walla Walla and its surroundings.*

Wallula is a clear, rapid creek, heading in Blue Mountain, and running westward to the Columbia River. In a dish-shaped valley, and some 30 miles from the mountains, lies Walla Walla, on both sides of the creek. Its population is some 3,000. It is a place of large business in all branches of trade, and is the objective point for the torrent of emigration at present heading for the Pelouse country. By irrigation, the soil gives evidence of great fertility, producing not only small grain, but the best of all sorts of vegetables, and probably the finest corn west of the Mississippi Valley. Fruit is also in abundance, of fine quality—not only apples, pears, and the like, but also grapes. The city is regularly laid out, and both as to extent of squares and ornamentation is not unlike the best settlements of Mormondom. The streets are planted with Lombardy poplars, which have made a rapid growth, and contribute much both to the appearance and comfort of the place. They have been irrigated up to the present time, but it is believed that they will eventually root deep enough in the loose soil to secure sufficient moisture.

### *Meteorological conditions.*

Three weeks were occupied in the determination in latitude and longitude of this station, from August 8 to 29. There was much electrical phenomena and some clouds to occasion delay, but there was no rain, nor had there been any to bless this land of dust since the March previous. There were observations August 10, 12, 13, 14, 16, 18, 19, 24, 25; August 15, 17, 20, 21, 22, and 23 cloudy—a week out of three, yet no rain. The night of August 22, while loitering at the observing tent, waiting for the clouds to disperse, a "chinook" was felt, but of brief duration. The "chinook" is a hot wind that comes from the sea, common in winter, and is particularly remarkable for the rapidity of its softening action upon the snow and frost-locked land.

### *Telegraphic communication.*

The connection was made with the Ogden Observatory by way of Boise City and Winnemucca. That portion of the line between Walla Walla and Winnemucca was in charge of Professor Speed—it having been but recently put in order for military purposes. It was a perpetual source of delay and worry. Men had to be kept out constantly looking after it. The poles were rotten and gave way daily from one cause or another, and the wire was seldom or never working twelve consecutive hours.

### *Method of observations.*

Observations were made with eye and ear; Mr. G. M. Dunn recording and giving other efficient service in addition to his meteorological observations. The chronometer for exchange of signals was taken to the telegraph office, distant some three squares. Sufficient preliminary computations were made to detect and rectify any possible error during the observations.

### *Instruments.*

Z. M. (Würdemann, No. 16). This instrument is old, much worn, and, if at its best, would be too small for the atmosphere of Walla Walla in latitude work. Chronometer Negus No. 1511 was used, having a very fair rate, despite the necessarily rough usage it got in the stage trip from Redding to Roseburg.

## ASTRONOMICAL STATION AT THE DALLES, OREGON, 1878.

### *Geographical position.*

The point selected for the determination in The Dalles was on the bluff of the lava bed, under the shadow of which are the Steam Navigation Company's offices and workshops. The pier was of cemented brick and in a position not likely to be disturbed, unless it be by some irrational wantonness. From here one can not only overlook the whole city, but have an unobstructed view of the lofty and snow-covered cone, Mount Hood: and but for a mountain ridge just across the Columbia River, Mount Adams would also be visible. From the pier the northwest corner section 3, township 1 north, range 13 east, bears north 33° west, distance 447½ feet; and to the south side of Main street, if it were prolonged, the distance is 81½ feet. (See plat herewith.) The meridian was marked on the north near the bluff facing the Columbia River by an iron pin driven into the ground and then covered by a conical pile of rocks 6 feet wide and 4 feet high. Southward on a large natural mound (which was once a part of the military reservation of old Fort Dalles) it was indicated in the same way.

### *Dalles City and surroundings.*

The Dalles, or Dalles City, in the language of its incorporation, is situated at the mouth of Mill Creek, a very considerable distance below the main part of the rapids of the Columbia River, from which it takes its name. It is a strangely selected spot for a city, for what is not lava bed is for the most part sand. Once there was a level and fertile valley between the city and the foot of the rapids, but that is now almost entirely covered with sand dunes. The wind that pours up the cañon, that sets in at the mouth of Mill Creek, like water through a funnel is apparently the source of all this sand in and about the city. Despite the forbidding character of the location, Dalles City is a picturesque go-ahead town, having many fine stores and pleasant residences, with their charming fruit gardens.

### *Meteorological conditions.*

It took no less than four weeks to put in this station, from August 29 to September 25. Arrangements for observations were ready the 31st. September 1, however, a violent wind carried everything in the shape of tent and other equipment to the ground, making it necessary to put up a substantial frame work. Observations were made, or it was possible to make them, September 2, 3, 4, 5, 6, 7, 8, and 9, although there was much embarrassment from the wind. From September 10 to 19, inclusive, the atmosphere was so full of smoke, driven from the burning Cascade Mountains, that no observations could be made. A few of the very largest stars could sometimes be faintly seen. During this time the sun was stripped of its power and stood in the heavens as a great blood-red orb; the moon had the same general appearance by night; the wind blowing all the while eastward, and sometimes violently. From the 19th to the 25th it was for most part favorable, if the wind be excepted.

### *Telegraphic communication.*

The Western Union office and that of the Oregon Steam Navigation Company not being connected in Portland, an effort was made at first to get Ogden by way of Walla Walla, Boise City, and Winnemucca. The most patient perseverance for many nights brought success but once in this direction, September 5. The office in Portland having been connected, the rest of the signal exchanges were made by Portland and San Francisco, that circuitous but expeditious route.

### *Method of observation.*

Mode of observation same as at Walla Walla; that is, eye and ear. The chronometer did not have to be taken so far; but the climbing up and down the bluff was anything but a safe or pleasant operation.

### *Instruments.*

Instruments same as at Walla Walla. No. 16 is an old instrument, has been put to much service in many places, but the roughest usage it ever had it received probably from the wind and sand of Dalles City, Oreg.

## ASTRONOMICAL STATION AT FRESNO, CAL., OCTOBER, 1878.

### *Geographical position.*

The location of the observatory was on a swell of ground some half mile south of town. Pier was of cemented brick, as the other stations. There was no lava bed here as at The Dalles, or bowlders as at Walla Walla, loaded with magnetic iron to affect the needle, the soil being composed almost entirely of sand. It is seldom or never possible to get such a desirable spot in all respects for an observatory as was here presented. The view was unobstructed in all directions, bounded eastward at a great distance by Mount Whipple, Goddard, and other great mountain masses of the Sierra Nevadas, while westward lay the Coast Range.

### *Fresno and its surroundings.*

Fresno is a town that owes its origin to the Southern Pacific Railroad. It is the capital of the county of that name, which is often designated in California as the county of colonies. The court-house is an expensive and showy building, and stands out in marked contrast with all other improvements, both public and private. At this season of the year there seemed to be no vegetation here—nothing green—except that produced by irrigation.

### *Meteorological conditions.*

Had the pier and tent in readiness for observations by October 1, and it was continuously clear till the 11th, when it rained, as also on the 13th and 14th. There was little or no wind, and no dust to interfere, notwithstanding the sandy soil.

### *Telegraphic communication.*

Ogden was got by way of San Francisco, and, there being no delay in the use of the wires, long exchanges with complete clock error could have been had every night from October 1 to 11 had the conditions of the former place been equally favorable.

### *Method of observation and instruments.*

Same as at other stations.

The elaborate stone pillars sent to Fresno for marking the meridian were placed; the one in the meridian north of the pier, just north of the railroad track, and on a line with the first row of houses facing south; the other about the same distance southward and near a road leading to one of the colonies.

Very respectfully, yours,

JOHN H. CLARK.

Capt. GEO. M. WHEELER, *in Charge.*

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## APPENDIX J.

### REPORT OF A SPECIAL ASTRONOMICAL PARTY OPERATING IN NEW MEXICO AND TEXAS, FIELD SEASON OF 1878, BY MILES ROCK, ASSISTANT.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
*Washington, D. C., May* 1, 1879.

SIR: In compliance with your orders to establish principal astronomical stations at Fort Selden, N. Mex., and Fort Bliss, Tex., I left Washington for the field July 12, 1878. At Philadelphia I met Prof. T. H. Safford and arranged a programme for star observations and the exchange of telegraphic time signals. Mr. Fred. W. Floyd, astronomical assistant and meteorologist of the party, joined me at Harrisburg. Your final instructions for the work awaited me at South Pueblo, Colo., and your telegram, at Santa Fé, N. Mex., authorizing me to delay the journey to observe the solar eclipse of July 29.

Lieutenant Paxton, Fifteenth Infantry, and acting commandant at Fort Marcy, loaned me two signal-service telescopes of about 2 inches aperture and 30 inches focal length. Obtaining some plain circular eye-glasses from a jeweler, I smoked and placed one within the cap of each eye-piece. The telescope supports were screwed into posts planted 10 feet north and south of the astronomical monument of this survey, the position of which, as determined in 1873, is latitude 35° 41′ 19″.29 north, and longitude 105° 56′ 45″.22 west from Greenwich. I obtained a correction for my mean-time chronometer (Negus No. 288) by telegraphic signals from Denver, giving alleged Washington true time. The chronometer was 8 minutes 8 seconds fast of Washington mean time.

The following is the result of the eclipse observations in Washington mean time:

Beginning of the eclipse:

| | h. | m. | s. |
|---|---|---|---|
| Rock | 4 | 17 | 51 |
| Paxton | 4 | 17 | 53 |

End of the eclipse:

| | | | |
|---|---|---|---|
| Rock | 6 | 33 | 43 |
| Paxton | 6 | 33 | 42 |

Each observer independently noted, near the end of the eclipse, the time of the phase that seemed equal to the phase which was first detected, marking on prepared diagrams the appearances that were timed. In this way a more accurate time for first contact was secured.

The actually-observed times were as follows, in chronometer time (Negus mean-time chronometer 288):

By Rock:

| | *h.* | *m.* | *s.* |
|---|---|---|---|
| Phase A, after first contact | 4 | 26 | 29 |
| Phase A, before last contact | 6 | 41 | 39 |
| Last contact | 6 | 41 | 51 |

By Paxton:

| | *h.* | *m.* | *s.* |
|---|---|---|---|
| Phase A, after first contact | 4 | 26 | 34 |
| Phase B, before last contact, equal to Phase A according to his diagram | 6 | 41 | 17 |
| Phase C, before last contact | 6 | 41 | 28 |
| Phase D, "gone," last contact | 6 | 41 | 59 |

Mr. Floyd had charge of the chronometer, and marked time. He and observer, Sergeant Frost, of the Signal Service, read the meteorological instruments every quarter hour during the eclipse, and every half hour during the remaining time from noon to 7 p. m. I also observed a thermometer exposed to the sun's direct rays with its bulb smoked.

While at Santa Fé, Mr. Floyd took comparative readings of the survey barometers with those of the United States Signal Service.

On July 30, we resumed our journey, and arrived at Fort Selden August 2, and staid two days to select the site and arrange for constructing the monument. However, in consequence of the abandonment of Selden as a military post, you subsequently selected Fort Bayard instead. Mr. Floyd took barometric readings in the hall of the commandant's house during our stay.

August 4 and 5 were spent at Las Cruces and Mesilla in efforts to secure materials and skilled workmen for building astronomical monuments, but without success.

On the morning of August 6 we arrived at El Paso (Franklin), Tex. It is also the present Fort Bliss, the troops being quartered in the village. The two old posts of this name are further down the river, 3 and 3½ miles, respectively, and are in ruins. I located the astronomical monument 25 feet northwest from the center of the public square, as shown by a plan of the town, and measuring from the buildings on the southeast and southwest sides. There is no other public ground, and it seems the only place secure against disturbance by future improvements; but being an open common and a rendezvous for cattle and teams, for its present protection I built a rough stone wall 2 feet high and 10 feet square around it. The mason and brick I could get only from El Paso, Mexico, and the brick had to be specially baked by a tile-maker. As the rainy season was at its height and would not permit observation, I waited until the brick pier was built before mounting the transit.

On August 15 I was ready to exchange signals with Professor Safford, at Ogden, but failed to get him, as the Western Union line was down beyond Santa Fé. Each night following I observed for time whenever clear enough, but failed to get a circuit with Ogden for over three weeks.

On August 19 I sought to get a circuit via San Diego and San Francisco, but no trial was made, as others supposed it useless, the distance being about 2,500 miles.

The weather began to settle about August 24, and then I observed for latitude, whenever clear enough, after trying each evening to get Ogden, and on the nights of August 24, 25, 27, 29, 30, and September 1, 2, and 4, observed 184 pairs of latitude stars.

The failure to get a circuit to Ogden via Santa Fé, Pueblo, Denver, and Cheyenne was due to various causes on different nights, but chiefly to interruptions of the line by storms in the Rio Grande Valley and on the stretch between Santa Fé and Pueblo, which was in very bad condition. Finally, fearing failure altogether in getting the longitude by telegraph, I proceeded to observe transits of the moon and moon-culminating stars on four nights before full moon, and, in order to make a complete set, three nights after the full, though by that time I had succeeded with the telegraph. These observations were made on the nights of September 5, 7, 9, 10, 11, 12, and 13, the moon's limb and about six stars on each night.

On September 6 I again tried to get a circuit via California, and on the evening of the 7th succeeded in exchanging time-signals with Ogden, and again on the nights of September 8 and 10. This line was then interrupted, but I finally obtained a circuit via Santa Fé and Cheyenne on September 11 and 12, which completed the observations at this station. There were observed 198 stars for time, of which 127 on the five nights when time-signals were exchanged.

Hourly readings of the meteorological instruments were taken for four weeks, and only at certain hours during the remaining two weeks of our occupancy of the station.

The north meridian-mark is situated nearly a mile off on the edge of a mesa skirting the base of Franklin Mountains, and 360 feet above the monument in altitude. The situation did not allow a south meridian-mark.

The post quartermaster, Lieut. D. J. Gibbon, Ninth Cavalry, furnished tents, tools, and furniture, and hauled lime, sand, brick, stone, and water, and extended all needed assistance.

On September 17, to carry out your instructions in regard to connecting my monument with the astronomical station of the Mexican Boundary Survey, I called on Señor Ramirez, in El Paso, Mexico, who had been one of the Mexican commissioners to locate the international boundary; he pointed out to me the spot, as he remembered it, for there is no mark of the astronomical station of that survey, near the church, with the bell-tower of which I connected it as near as practicable by pacing. It is 140 feet south and 350 west from the tower.

On September 18 we started for Fort Bayard, by an Army escort wagon, furnished by Lieutenant Gibbon. I could thus carry the instruments along, and have them at hand as soon as wanted at Bayard. We took cistern-barometer readings at all the night stopping places; at Cottonwood Ranch, south of old Fort Fillmore; at Mesilla comparative readings with the signal-service barometer; at Mason's ranch, west of Fort Selden; at the spring at old Fort Cummings; and at Miembres Hot Spring, at the foot of the mound of the spring in front of the dwelling.

We arrived at Fort Bayard on September 23, and the same day I located the site for the monument on the solid gneiss rock on top of a hill just outside the quadrangle of the post, about 400 feet from its western corner, and 34 feet in altitude above the surface of the parade-ground at the flagstaff, and in the evening staked out the meridian.

Next day, the 24th, I took our wagon to Silver City, nine miles west of Bayard, for lime and brick, and on the 25th, with the help of a Mexican mason from Central City and a discharged cavalryman, the observing pier was erected. The same evening I set up the transit and was ready to exchange time signals; but the office of the military telegraph was closed, on account of the absence of the operator on repair duty.

Lieut. James Allen, A. S. O., and superintendent of the Sante Fé division of the military telegraphs, ordered an operator up from Silver City in time for the next evening, September 26, when I obtained a circuit via San Diego and San Francisco, and exchanged time signals with Professor Safford at Ogden, Utah; also, on the nights of September 27, 30, and October 1 and 3. There were observed 144 stars altogether for time determinations, and 110 on the five nights when signals were exchanged. There were 65 time signals received from Ogden, and the same number sent each night here, as well as at Fort Bliss.

For latitude there were observed 190 pairs of stars on the nights of October 4, 6, 7, 8, and 9.

The north meridian mark is distant 580 yards on a hill of the same height as Monument Hill; the south mark 820 yards on a lower rise west of Central City.

The meteorological instruments were read hourly during the whole of our stay. On October 8 I sent Mr. Floyd to Silver City with one of the cistern barometers to take comparative readings with the signal-service barometer.

I examined a ledge of white marble near the Hanover copper mines to see if it would furnish blocks for monument caps and meridian-mark stones, and concluded a contract on October 10 to quarry, cut, and letter the stones for both stations and place those of Bayard into position.

Lieut. D. R. Burnham, Fifteenth Infantry, post quartermaster, hauled sand and water and furnished an observatory tent, tools, and furniture and quarters for Mr. Floyd and myself. On October 10 the instruments were prepared for shipment and the public property turned over to the post quartermaster.

On the 11th we started on our return journey on the bi-weekly buckboard. At old Fort Cummings the same day we fell in with Mr. Nell's section of Lieutenant Birnie's party of this survey and compared barometers.

At Mesilla, on the 12th, we took comparative readings with the signal-service barometer, and again at Santa Fé on the 17th.

On my arrival at Santa Fé, October 16, I received your telegraphic order to proceed to Fort Dodge, Kans., and arrived there on October 20. At the post, five miles from the town, your note was received directing me to select a site, estimate the expense, and obtain all needed information for the subsequent establishment of an astronomical station. All which was done on Monday, the 21st, the site selected being the southwest corner of the court-house yard, which is the only public ground on a high part of the town affording a horizon. The same night I started for Washington.

Very respectfully, your obedient servant,

MILES ROCK, C. E.,
*Civilian Assistant, in charge of the party.*

Capt. GEORGE M. WHEELER, *in Charge.*

## APPENDIX K.

### PRELIMINARY REPORT OF A SPECIAL GEOLOGICAL PARTY OPERATING IN COLORADO AND NEW MEXICO, FROM SPANISH PEAKS TO THE SOUTH, FIELD SEASON OF 1878, BY PROFESSOR JOHN J. STEVENSON, ASSISTANT.

UNIVERSITY OF THE CITY OF NEW YORK,
*New York, April* 10, 1879.

SIR: I have the honor to submit herewith a preliminary report upon the geology of the portions of South Central Colorado and North Central New Mexico examined by me during the field season of 1878.

I may here gratefully acknowledge the uniform courtesy shown me by the officers at Forts Union and Garland. To the kindly co-operation of these gentlemen is due not a little of the success marking the season.

Very respectfully, yours,

J. J. STEVENSON.

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### GENERAL PHYSICAL FEATURES OF THE DISTRICT.

The region examined during the season of 1878 includes part of South Central Colorado and of North Central New Mexico. It is embraced between north latitude 37° 20′ and 35° 40′, and longitude 104° 7′ 30″ and 105° 30′ west from Greenwich. It is represented on atlas-sheets 70 A and 70 C, and its area is not far from 8,000 square miles.

The western part of this region is mountainous, as the Sangre de Cristo Range of Southern Colorado enters it and expands into a group of ranges. At the north the mountains break down abruptly toward the east, and are separated by a narrow longitudinal valley from the Raton Mountains, which on the map are colored as coextensive with the Laramie or Lignitic group. Near the extreme north a high, basalt-covered area, marked on atlas-sheet 70 A as the Raton Plateau, extends eastward from the Raton Mountains, and merges into a great volcanic area beyond the limits of the district.

On the south and east the Raton Mountains look upon the Canadian plains, a broad expanse of rolling country, dotted here and there with low mesas or flat-topped hills, and extending southward and eastward far beyond the region examined. The streams flow across this plain-country in rapidly deepening channel-ways, which become great cañons toward the south and southeast.

The mountain area expands southward for, say, 70 miles, but thence it contracts. The eastern or Cimarron Range breaks down southward, and is lost in a great mesa, which will be spoken of in this report as the Ocate mesa, while the next range at the west bends westward, and the low mesa country is carried almost to the western edge of the district before the southern edge has been reached. The change in the conditions is well shown on the map; for at the north the whole of the mountain area falls within the district, and the plains of the Rio Grande are reached on the west side, whereas southward the expanding of the mountain groups carries a great mountain region out beyond the western border, while at the same time the gradual dying out of some of the eastern anticlinals and the curving westward of others throws almost the whole of the mountain area beyond the western edge of the district.

The region under consideration includes parts of three great drainage areas: that of the Purgatory, that of the Canadian, and that of the Rio Grande. The first two are really subdivisions of the great Arkansas area, but as far as concerns the present report they may be considered as wholly independent.

The area of the Purgatory, which occupies the northern part of the district, begins on the west slope of the Culebra Mountains and extends eastward to beyond the limit of the map. It is the seat of extensive agricultural and mining operations. The important city of Trinidad is the commercial center. The area, however, is narrow and lies north from a line passing east and west through the Raton Plateau. The Canadian area is by far the most important, for it includes all that part of the district lying south from the line already indicated and east from the mountain divide. Economically, its northern portion is as important as the Purgatory area, but the developments have not been carried to so great an extent either in agriculture or in coal mining. The area of the Rio Grande lies wholly west from the mountain-summit, as far as the work of last season is concerned, but the divide between it and the Canadian bends to the east immediately south from the region examined, so that thence southward the waters from both sides of the mountain ranges are drained into the Rio Grande.

### THE DIVIDES.

The divide separating the areas of the Purgatory and Canadian from the area of the Rio Grande may be best considered as a unit, as indeed it is, separating as it does the

Rio Grande area from that of the Arkansas, of which, as already stated, the areas of the Canadian and Purgatory are but insignificant divisions.

Beginning at the northern limit of the district, we find this divide, there known as the Culebra Range, to be but a continuation of the Sangre de Cristo Range, to which sufficient reference has been made in my previous report. The divide coincides with the summit of the range for a distance of, say, 20 miles, when it bends eastward, or rather is shifted east, a few miles. The southerly course is resumed and retained to the head of Comanche Creek, where it bends westward. It now coincides again with the summit of the main mountain range and so continues to the most southern point reached during the season. The divide is the same with the summit of the mountain ridges marked on the map as the Mora and the Las Vegas.

The passes over the divide are not numerous, and few of them show gentle approaches. The first, beginning at the north, is Costilla Pass, leading from Vermejo Creek, a tributary to the Canadian, to Costilla Creek, a tributary to the Rio Grande. The approach from the west is very gradual, and the summit of the pass is a broad, open, and somewhat rolling plain; but the approach from the east is abrupt, though the difficult grade was easily overcome by making the road serpentine. This pass is but 10,147 feet high at the summit, and is said to remain open during nearly the whole year. But it is little used now, for, although the summit is not likely to remain closed, the approach on the west side is liable to be badly blocked with snow in some narrow defiles. Moreno Pass leads from the head of Comanche Creek, a tributary to Costilla, to the head of Moreno Creek, a fork of Cimarron Creek, which enters the Canadian. This is a low, gentle pass, with easy approaches on each side, but liable to be choked with snow at an early date. It is somewhat uncertain, as the ground is marshy for some distance on each side of the summit. The pass is not thought to be a good one, as it is more apt to close quickly during snow storms than are some of those which are higher and more abrupt.

Red River Pass, leading from the west fork of Moreno Creek to the head of Colorado Creek, was much used while the Moreno mining district was prosperous. An excellent wagon-road was constructed, but since the decay of mining interests the road has been little used and it is in a dilapidated condition. The approach from the east is comparatively gentle, but the grade on the west side is extremely abrupt, difficult indeed for loaded animals. Unless the grade were very materially better in earlier days one can hardly conceive how wagons could have been taken over it. The grade for one mile is nearly ten degrees.

Taos Pass leads from Moreno Valley to the head of Ferdinand Creek and is crossed by the stage-road to Taos. The approach on each side is a comparatively gentle grade until within half a mile of the summit, but thence the grade is very difficult. The pass is 9,095 feet high and is kept open during the winter. Like that of the Red River Pass, the summit of this is exposed, and there is little opportunity for snow to accumulate during the driving storms which prevail. Much freighting is done over this important pass.

A wagon-road, crossing the Mora range from Black Lake on Coyote Creek to a fork of Frijolé Creek, was constructed many years ago for government use; but it followed no pass, and the grade was so bad that when no longer needed by the government teamsters the road was abandoned.

The Las Vegas Mountains present a regular crestline towards the Mora River, a tributary of the Canadian, and two roads cross from Mora Creek to the streams forming Junta Creek, tributary to the Rio Grande. The northern road winds up the mountain side with a painful grade lasting for nearly three miles, but over the summit, on the waters of Junta Creek, the grade is not so difficult. The approaches on both sides are easier along the other road. Both roads are said to remain freely open during the whole winter. No other passes exist along this divide within the district, the distance included being not far from 140 miles. A few trails have been used by the Indians, but, for the most part, these are hardly practicable for loaded animals. One such trail passes from the south fork of the Purgatory to the north fork of Culebra Creek; another, from the Moreno Valley to Lucero Creek, and another from the head of Mora Creek to a fork of Frijolé Creek. These are very obscure, and are badly obstructed with fallen timber, so interlaced that progress is almost impossible.

The divide between the Purgatory and the Canadian begins on the west slope of the Culebra Range, and follows a tortuous course through the Laramie area to the Raton Plateau, and thence to beyond the district at the east. The passes are numerous and for the most part unpleasantly abrupt near their summits.

A gentle pass leads from the Purgatory to the Vermejo in the narrow valley at the base of the range. It is crossed by a good wagon-road and is 9,176 feet high at the summit. A good pass leads from Long's Cañon, tributary to the Purgatory, to the head of the Upper Canadian, and thence to Vermejo Creek. It is followed by a wagon-road, leading from Trinidad to Elizabethtown in the Moreno Valley. Two passes lead from Dillon's Cañon, tributary to the Canadian, to the waters of the Purgatory; the one crossing to Long's Cañon, and the other to Chicken Creek, which empties into Raton Creek. The latter is said to be an excellent pass. The former has gentle approaches on the Canadian side, but for two miles from the summit, on the other slope, it is painfully steep. Raton Pass leads from Willow Creek to Raton Creek, and for many years it has been the most important of the passes over this divide, for the Santa Fé stage and freight road crosses by it. The road is excellent and the grades are good, except near the summit on the Raton side, where, for more than half a mile, the grade is steep, and the pass is hardly available during muddy weather. The soft shales readily break down into mud, and in long-continued wet weather the road seems to become almost bottomless. This pass has been used by the Atchison, Topeka and Santa Fé Railroad, as the distance through the hill, near the summit, is insignificant and the abrupt grades are avoided by a short tunnel.

Manco Burro Pass leads from the head of Chico Rico Creek, a tributary to the Canadian, to the head of San Isidro Creek, flowing to the Purgatory. It is approached from the north or Purgatory side by two roads, one skirting the wall of the Mesa and approaching the pass by comparatively easy grades, the other following up San Isidro Creek. Either of these is available for pack animals and the former is easy for wagons. The roads come together at the foot of the direct ascent to the summit, which is of not so good grade. Still, it is not much more difficult for wagons than the corresponding portion of Raton Pass, on the north side. The approach on the southern or Canadian side is not easy, but it is passable for wagons.

The subordinate divides will be described in the final report on this region.

### THE STREAMS.

A few more notes respecting the streams may not be out of place here, as the map will not accompany this preliminary report.

The Upper Purgatory River is formed by the union of several branches within the the Laramie area at not far from the base of the Culebra Range, and flows irregularly eastward to beyond the limits of the district. The several streams forming its forks flow through deep, though short, gorges and unite for the most part within the narrow longitudinal valley at the base of the range. Below the junction of the forks the river flows through the Laramie area in a broad cañon with walls of varying abruptness, which seem to gain somewhat in altitude toward the plains. Long tributary cañons enter that of the main stream from both sides, all of them heading on the Laramie Plateau, which is known as the Raton Mountains.

The Canadian River is formed by the union of the two streams, both having their source in the Laramie area, the one formed by petty creeks rising under Manco Burro and Raton passes, the other rising at the top of the plateau farther west. These unite in the Canadian plains, and thence the river flows southeastwardly to beyond our limits. Its channel-way deepens rapidly and, at, say, 70 miles south from the northern edge of the district it enters a cañon which, where last seen during the season, is 1,090 feet deep. This stream receives many important tributaries from the west, of which Vermejo and Cimarron Creeks have their sources in the mountains and drain a great part of the Laramie area. Ocate Creek drains much of the Ocate mesa, while Coyote, Mora, Cebolla, and Sapello creeks, draining the whole of the mountainous region at the south, unite to form the Mora River, which enters the Canadian near the southeast corner of the district. This large river flows in a dismal cañon similar to that of the Canadian.

### THE ANTICLINALS.

The anticlinals of the region fall naturally under three series, thus:

#### THE CULEBRA AXIS AND ITS SUBDIVISIONS—THE CIMARRON AXIS, AND THE SUBORDINATE AXES OF THE RATON MOUNTAINS OR AREA OF THE LARAMIE GROUP.

The Culebra axis enters the district at the north and seems to be the continuation of the Sangre de Christo Range, though this statement may not be made positively, for I had no opportunity to determine its accuracy. The axis is marked by the Culebra Range, and, so far as can be ascertained, remains simple until a short distance south from Costilla Creek, the line between Colorado and New Mexico, where a fault begins, which apparently marks the origin of the strong Mora anticlinal. The western part of the axis beyond the fault evidently ends at a little way north from Ferdinand Creek, or not far south from Taos Peak, and the new axes are found west from the Mora anticlinal. These I have designated as the Santa Fé and the United States axes, the names being taken from the ranges which show the course of the anticlinals.

Little information was obtained respecting the Santa Fé and United States axes, as they lie altogether beyond the western limit of the district, and were reached only incidentally during a detour made to secure information concerning the west slope of the Mora axis. They remain to be examined during a coming season. The synclinal between the Mora and the Santa Fé axis contains only rocks of the Carboniferous age, and no rocks of later age are involved in the axes themselves. The age of the rocks between the Santa Fé and the United States axis was not fully determined, but it seems to be only Carboniferous in the northern part of the trough, to which alone my examinations were confined.

The Mora anticlinal is a bold axis with a distinct Archean core, and follows an almost north and south course to Cebolla Creek, where it bends westward and follows a southwest course to the southern boundary of the region examined. A great fault was found on the west slope of this fold whereby the Archean rocks are exposed southward from Mora Creek to Sapello Creek. A distinct subordinate anticlinal occurs on the western slope, and is apparently the northward continuation of this fault. Carboniferous rocks alone are involved in this axis.

The Coyote synclinal, between the Culebra-Mora axis and the Cimarron axis at the east, presents some extremely complicated stratigraphy, which has not been worked out in detail, though the general structure is now quite clear. It is hoped that after the short season of 1879 I shall be able to present the structure of this interesting synclinal in all needed detail. Unlike the synclinals at the west, this one holds rocks belonging to the Mesozoic, even those of the Laramie Group.

The Cimarron anticlinal appears as an anticlinal first near Ponil Pass, immediately north from the Old Baldy Mountains, but it is easily followed north far beyond the disappearance of anticlinal structure; for the strata on the east slope of the Culebra Range are violently distorted even to the northern limit of the district. The axis increases in height to beyond Cimarron Creek, but thence southward declines until it finally disappears in an upturned wall of Dakota sandstone in the synclinal at the west. Unlike the other axes, this involves the newer rocks, and at Ponil Pass it is crossed by those of the Laramie Group.

The Cimarron axis is scarcely less interesting than the Coyote synclinal, intervening between it and the Mora anticlinal at the west.

### THE SUBORDINATE ANTICLINALS.

Several small anticlinals were observed in the Raton Mountains, and one occurs in the southern part of the district, which is crossed by the Canadian River at but a few miles below the head of the cañon. These anticlinals are not parallel to each other, though there is a close relationship existing among all except that lying nearest the mountain range. For the most part these axes are gentle, with dips seldom exceeding two or three degrees. But the Vermejo axis, the most western of all, shows dips ten degrees on each side. It differs from the others in that its course is nearly north and south, while the others have a north-northeast to northeast trend. These minor axes have decided economic importance, for to their influence is due the accessibility of the lignitic rocks over an extensive area. The Raton anticlinal, passing but three or four miles west from the summit of Raton Pass, is as abrupt as the Vermejo, and its slopes are quite as short. It brings up the great *Trinidad coal bed* to the surface.

The minor axes, in the order of their occurrence, are the Vermejo, the La Junta, the Raton, and the Canadian. In addition to these is the peculiar uplift, the Turkey Mountains, in the neighborhood of Fort Union. This seems hardly to be a true anticlinal, but its features have not been ascertained satisfactorily. The dip is in all directions from a central point and its existence is due probably to volcanic action, which was so energetic in its immediate vicinity.

### THE ARCHEAN AREA.

This area is continuous on the western side of the district. It enters at the north and forms the axis of the Culebra Range, continues through the Taos and the Mora Ranges, and passes into the Cimarron Range across the northern part of the Coyote synclinal. It is very broad at the north, though the overflows of basalt have covered much of it on the west side of the Culebra and Taos Ranges. In like manner it is concealed greatly in the Cimarron Range and to a slight extent on the east side of the Mora Range. The Santa Fé and the United States anticlinals show Archean rocks, but those areas are separated from the main area and lie wholly outside of the region assigned for examination during 1878.

The rocks within this area show great uniformity in character. In the Culebra Range there is much coarse gneissoid granite, with here and there some gneiss and mica schist. But near Costilla Creek the general condition changes, and there the prevalent rock is dark gneiss, very fine grained and compact, which is not wholly unlike sandstone in its general appearance. With this there occurs also white quartzite in broad bands, which is of frequent occurrence southward in the Coyote synclinal, along Comanche Creek and the north fork of Moreno Creek. No chloritic rocks were seen except on Costilla Creek, where some thin beds of those rocks occur in close relation to a dike of trachyte.

In the Taos Range, exposures were found only on the east side, where coarse gneissoid granite prevails, though here and there one finds a mottled gneiss, with some beautifully waved schists containing silvery mica. A fine-grained, somewhat greasy gneiss, is frequently shown in the Moreno Valley, between the Taos Range and the Cimarron Range. In the Cimarron Range the gneiss is dark, compact, and cleaves like wood. It holds few streaks of quartz, but here and there it shows blotches of gneissoid granite, which is extremely coarse.

The area of Archean rocks becomes very narrow along the Mora anticlinal southward from Taos Pass. The axis of this anticlinal does not coincide with the topographical range designated on the map as the Mora Range, but lies between Mora Creek and Coyote Creek, and passes almost directly through the towns of Mora, Cebolla, and Santo Nino. The exposures under this anticlinal are very distinct. Along the slope facing Coyote Creek the rock is fine-grained, white gneiss, containing silvery mica. But nearer the axis of the fold the character changes, and the prevailing rock is a fine-grained gneiss, so like unaltered sandstone that one examining only hand specimens might well hesitate before positively assigning it a place. But this rock passes gradually into a dark, micaceous schist, or schistose gneiss, and is much contorted. It contains many thin veins of quartz. The character of the rock changes little southward to the farthest point reached during the season. Coarse gneissoid granite, gneiss, and micaceous schists prevail everywhere. The absence of hornblende rocks is a noticeable feature, none having been found anywhere except in the Mora axis, on Ferdinand Creek, at a few miles south from Taos Peak.

Under the Santa Fé axis a fine-grained, compact, and almost white gneiss was observed. It seems to be the only rock representing the Archean age there.

### THE CARBONIFEROUS AREAS.

The areas of Carboniferous rocks are somewhat disconnected. The northern area begins with the district and extends southward along the eastern slope of the Culebra Range to near Costilla Peak, where it ends somewhat abruptly.

Within this the succession is, first, a mass of coarse reddish to grayish red sandstones and conglomerates, in all probably 3,000 feet thick; below this are reddish sandstones and shales alternating with limestones and passing into a coarse conglomerate which rests on the Archean. No successive exposures were accessible whereby a detailed section could be obtained. Three beds of limestone were observed, all of which are clearly of Coal Measures age. The lowest of them, resting on the lower conglomerate, contains no species except those which may be regarded as Coal Measures forms.

Near Costilla Peak the Carboniferous rocks run out against the Metamorphic rocks.

The second area is in the Coyote synclinal, which lies between the Cimarron Range and the Mora axis. Carboniferous rocks are not present on the east side of the synclinal at the north, where the Cimarron axis is strong, but they occupy an earlier trough on the west side of the synclinal, where they lie unconformably beneath Dakota rocks. This area, following the east slope of the Mora axis, begins very near the latitude of Elizabethtown and continues southward to the southern limit of the district. It is more than probable that the examinations of a succeeding season may show that it is connected with a third area occupying the synclinal between the Mora and Santa Fé axis.

The conditions within this area are in marked contrast to those observed in the forformer one. The coarse conglomerate, there capping the series, is wanting, the rocks are finer in grain in the upper portion, and the limestones are increased in number and thickness; but the great conglomerate which was observed at the base on the Culebra Range has become thicker and coarser, so that near the northern exposures in this synclinal it holds huge blocks of the Archean rocks. Here, too, it contains a limestone about midway, which, however, is non-fossiliferous.

Still farther south in this synclinal the change is more marked, for the great conglomerate at the base of the series disappears, a siliceous limestone rests directly on the Archean, and limestones are still further increased in number and thickness, so that on Mora, Cebolla, Manuelitos, and Sapello Creeks the lower part of the series is largely made up of thick limestone beds. A change occurs also in the higher beds of the group. Instead of the coarse conglomerates and the reddish sandstone and brownish red sandy shales, which are present on the Culebra Range as well as in the extreme northern portion of the Coyote synclinal, one finds a mass of gray sandstones in thin beds, separated by thinner beds of red shale, with occasional limestones in the latter. This condition begins near the head of Coyote Creek and continues southward as far as the season's work was carried. An insignificant area of Carboniferous was seen in the heart of the Turkey Mountains, where the gray sandstones and red shales are exposed. No limestones were observed, but Dr. Newberry obtained fragments of *stigmaria* from these sandstones, which at once fixes their age.

The third principal area occupies the synclinal between the Mora and Santa Fé axes. Little investigation was made in this synclinal, as it lies almost wholly beyond the western limit of the district. No detailed sections were obtained anywhere, and the examinations, for the most part, were such as could be made during a hasty reconnaissance. The Carboniferous rocks are not reached in the cañon of the Canadian River within the district; and no rocks belonging to this age were seen on the west side of the Culebra Range. Indeed, they seem to be absent from the west side of the mountains northward from Taos Peak.

### THE JURA-TRIAS AREAS.

The Jura-Trias rocks are exposed to but a slight extent. The longest continuous exposure is in the Canadian and Mora cañons, where the series underlies the Dakota sandstone and has a thickness, as exposed, of about 250 feet. A thin, blue, slaty limestone, without distinct fossils, is the highest member of the group. Below this are sandstones, gray and olive, with a grayish limestone at the base, resting on red shales mottled with white.

A petty exposure exists in the Turkey Mountains on the east side, where the rocks, as far as seen, resemble those shown in the cañons of the Mora and Canadian.

Within the mountain area exposures of these rocks are very rare. The whole series is evidently absent from the Culebra Range as well as from the northern part of the Coyote synclinal, where the Dakota Group rests directly on the Carboniferous. But these rocks do make their appearance in that synclinal on Coyote Creek below Guadalupita, and the total thickness of the series is not far from 700 feet. In the upper 200 feet some impure limestones occur, but there is none lower down, where only coarse sandstone and shales appear.

But the condition changes farther south within this synclinal, for on Mora Creek the series is represented by fine red shales and fine-grained sandstones, the latter containing rows of quartz pebbles. What the character of the rocks is on the streams farther south was not ascertained.

No Jura-Trias rocks occur on the Mora anticlinal or the Mora side of the Coyote synclinal. They are shown only on the Cimarron side of that synclinal. They are wholly absent from the synclinal between the Mora and Santa Fé anticlinals.

### THE DAKOTA AREAS.

The Dakota Group is exposed in two areas; the first on the east slope of the Culebra Range, from Cucharas Pass at the north to Costilla Peak at the south; the second, a continuous though very irregular area underlying the Ocate mesa at the west, and showing a continuous outcrop along Coyote, Mora, and other streams in the Coyote synclinal, and underlying the great Canadian plains southward from the head of the Canadian Cañon. Indeed, the Dakota is the prevailing rock in the southern part of the district, except where basalt overflows have concealed all.

This group is represented only by sandstone in the northern area, where it varies from fine-grained sandstone to moderately coarse conglomerate. Smooth quartz pebbles are numerous in the coarser beds, and thin *films* of quartz give a honeycomb structure to the finer ones. No fossils of any sort were observed here. The thickness is not far from 300 feet.

In the southern area, the conditions are varied. The rock forms the rim of the Canadian Cañon, where it is only sandstone and about 650 feet thick. Sandstone alone was seen on the Canadian plains and in the Long Cañon of the Mora, but on Sapello Creek, where the group is turned up sharply below the village of Sapello, the composition is quite different; for there one finds shales and sandstone with some argillaceous limestone. The shales, however, appear to be wanting at all exposures north from Cebolla Creek, and certainly there are no shales in the Turkey Mountains or on the broad mesa stretching from those mountains to Coyote and Mora Creeks.

No *coal* was observed anywhere within rocks of this series; the whole mass seems to be practically non-fossiliferous, and no remains of plants or animals were found, aside from some indistinct fucoids in thin-bedded sandstones at the very summit of the section.

### THE COLORADO AREAS.

The Colorado Group of King and Hayden includes the numbers 2, 3, and 4 of Meek, as published by him in the Memoirs of the *American Academy of Science* in 1856. These groups show some variations, and at times there seems to be much difficulty in separating them; but the Niobrara and Fort Pierre subgroups, Nos. 3 and 4, are thoroughly persistent and independent. Some doubt may exist respecting the propriety of separating the Fort Benton Group, No. 2, from the immediately underlying Dakota. These pass into each other so gradually that it is not always possible to draw a line of separation between them.

The rocks of the Colorado Group are exposed first along the east slope of the Culebra Range from the north limit of the district southward to Costilla Peak. Beyond this southward the series is buried under igneous overflows.

Insignificant patches of this group remain in the northern portion of the Coyote synclinal, but further south the newer portion of the synclinal becomes exceedingly shallow, owing to the decreasing importance of the Cimarron axis, and the Colorado rocks have been almost wholly removed from it.

The Colorado rocks are finely shown on the plains of the Canadian and Purgatory, and they surround the Laramie area, forming part of the bluff overlooking the plains. The higher members of the group fringe the Ocate mesa almost to its southern border. They have been removed by erosion from a large part of the plains lying between the cañons of the Mora and Canadian, but extensive remnants remain in mesas, many of them preserved by the hard cap of basalt.

The members of this group show little variation within the region examined. The *Fort Benton* sub-group, No. 2 of Meek, is rarely exposed in the Culebra area, but it is fairly well shown near the head of the Canadian Cañon, on the eastern edge of the Coyote synclinal at the south, as well as at several localities farther south, beyond the end of the Cimarron anticlinal. At all localities it is represented by a very dark brown, more or less sandy shale, which becomes more sandy toward the base until it passes imperceptibly into the Dakota sandstone below. No fossils were found in it aside from the characterless fucoids, which belong alike to it and to the Dakota.

The *Niobrara* subgroup, No. 3 of Meek, shows comparatively little variation in character. It is represented by bluish, earthy limestone, alternating with variegated shale, which, however, is mostly quite dark. The series evidently becomes thicker as it recedes from the old land area of the mountains, for it is not less than 700 feet on the Canadian plains along the line of Cimarron Creek, whereas it is much less on the side of the Culebra Range. The limestones are richly fossiliferous at almost all localities, and in all respects the rocks bear exact resemblance to those of the same subgroup in Central Colorado.

The *Fort Pierre* sub-Group has a thickness of probably 1,200 feet, but this could not be determined with accuracy, as exposures in the plains occur only along the streams. These, though almost continuous, are not sufficient to show the thickness of the group satisfactorily. The series consists of shales, varying from argillaceous to arenaceous, brown, drab, and gray, to blue and almost black. For 450 feet at the top, the shales are crowded with concretions, calcareous and ferruginous. The former occur higher up than the latter, and are more frequently fossiliferous.

This subgroup is best exposed in and near the bluffs facing the plains on the east side of the Laramie area. It is exposed also on the west side of that area along a narrow valley following the base of the Culebra Range, and extending from Cucharas Pass at the north to Costilla Peak at the south. Through the influence of the Vermejo anticlinal, its shales are brought up within the Laramie area, on Vermejo Creek and on the south fork of the Purgatory River, where they show the same features as on the plains and at the base of the mountains.

The rocks of this subgroup are seldom exposed within the space represented on map 70 C. They crop out under the east edge of the Ocate mesa, under the basalt cap of the Canadian Hills, and some insignificant mesas have been spared between Cebolla and Sapello Creeks.

The Fort Pierre shales pass imperceptibly upward into the Laramie Group, there being no Fox Hills Group in this region, unless that include also the Laramie or Lignitic, which, as seems to me, is by no means improbable. The junction of the Laramie and Colorado Group is well shown along the whole face of the bluffs toward the plains, as well as along the streams issuing upon the plain from the area of the Laramie rocks.

### THE LARAMIE AREA.

The Laramie Group is exposed throughout one compact area, co-extensive with the rolling region lying east from the Culebra and Cimarron Ranges, between them and the plains. In the northern part of the district this area is carried eastward to beyond Trinidad by the Raton Plateau, whose basalt cap has preserved the Laramie rocks from erosion, so that they extend as far east as, say, four miles beyond Manco Burro Pass. But the eastward rise of the rocks makes the Laramie section very thin east from the line of Raton Pass. No Laramie exists in the plains north or south from the Raton Plateau, and the final eastern outcrop is at nearly 2,000 feet above those plains immediately north from Manco Burro Pass. The portion of the area falling within the district is not far from 1,800 square miles; the area extends north beyond the district to Cucharas Creek, but tapers in that direction, so that the whole extent is not more than 2,200 square miles.

This area is cut by many cañons, of which those made by the Purgatory River, Vermejo, Cimarron, and Ponil Creeks cross the whole area, while Dillon's Cañon and that of the Upper Canadian, of Crow Creek, and some others expose the whole section of the Laramie Group. Sections were made in nearly all of the cañons opening upon the plains as well as in many minor cañons opening into those through which the larger streams flow. The process of tying together fragmentary sections is far from being simple, for no limestones exist which may be used as horizons, and the sandstones so closely resemble each other that they cannot be used as more than merely local guides. The detailed sections obtained during the season will be given in the final report, though it may be thought best not to encumber that report with any sections except such as give direct information respecting the succession of the beds. These indicate but a small amount of the physical labor performed in securing material for a generalized section of the group. This section is as follows:

*Section of Laramie Group.*

| | | |
|---|---|---|
| 1. | Sandstones and shales | 440′ |
| 2. | *Coal bed (Z)* | Blossom. |
| 3. | Sandstone and shale | 77′ |
| 4. | *Coal bed (Y)* | Blossom. |
| 5. | Sandstone and shale | 75′ |
| 6. | *Coal bed (X′)* | 2′ |
| 7. | Shale and sandstone | 45′ |
| 8. | *Coal bed (X)* | 4′ |
| 9. | Sandstone and shale | 26′ |
| 10. | *Coal bed (W)* | 6′ to 4″ |
| 11. | Sandstone and shale | 47′ to 70′ |
| 12. | *Coal bed (V)* | 4′ to 10″ |
| 13. | Sandstone and shale | 30′ to 36′ |
| 14. | *Canadian coal bed (U)* | 6′ to 4″ |
| 15. | Sandstone and shale | 26′ to 30′ |
| 16. | *Coal bed (T)* | 6′ to 2′ 6′ |
| 17. | Sandstone and shale | 13′ to 20′ |
| 18. | *Coal bed (S)* | 4′ 3″ to 10″ |
| 19. | Shale and sandstone | 25′ |
| 20. | *Coal bed (R′)* | 1′ 4 |
| 21. | Shale and sandstone | 25′ to 35′ |
| 22. | *Caliente coal bed (R)* | 16′ to 1′ |
| 23. | Sandstone and shale | 30′ to 35′ |
| 24. | *Raton coal bed (Q)* | 3′ to 1′ |
| 25. | Sandstone and shale | 25′ |
| 26. | *Coal bed (P)* | 2′ 6″ to 1′ |
| 27. | Sandstone and shale | 40′ to 50′ |
| 28. | *Coal bed (O)* | 10″ |
| 29. | Sandstone and shale | 30′ |
| 30. | *Coal bed (N)* | 2′ |
| 31. | Sandstone and shale | 33′ to 43′ |
| 32. | *Cameron coal bed (M)* | 33′ to 4″ |
| 33. | Sandstone and shale | 22′ to 27′ |
| 34. | *Coal bed (L)* | 1′ to 8″ |
| 35. | Sandstone and shale | 64′ to 70′ |
| 36. | *Coal bed (K)* | 3′ |
| 37. | Sandstone and shale | 24′ |
| 38. | *Coal bed (J′)* | Blossom. |
| 39. | Sandstone and shale | 44′ to 52′ |
| 40. | *Long's Cañon coal bed (J)* | 8′ to 1′ |
| 41. | Sandstone and shale | 45′ to 83′ |
| 42. | *Coal bed (I)* | 2′ 6″ to 2′ |
| 43. | Sandstone and shale | 50′ |
| 44. | *Coal bed (H′)* | 1′ |
| 45. | Sandstone and shale | 50′ to 60′ |
| 46. | *Cat's Claw Cañon coal bed (H)* | 5′ to 2′ |
| 47. | Sandstone and shale | 90′ to 111′ |
| 48. | *Upper Vermejo coal bed (G)* | 2′ to 2′ |
| 49. | Sandstone and shale | 60′ to 120′ |
| 50. | *Lower Vermejo coal bed (F)* | 9′ to 4″ |
| 51. | Shale | 12′ |
| 52. | *Coal bed (E″)* | 1′ |
| 53. | Shale and sandstone | 15′ |
| 54. | *Coal bed (E′)* | 6″ |
| 55. | Shale and sandstone | 25′ |
| 56. | *Upper Reilly coal bed (E)* | 7′ 8″ to 2′ |
| 57. | Sandstone and shale | 18′ to 31′ |
| 58. | *Lower Reilly coal bed (D)* | 6′ to 2′ |
| 59. | Sandstone and shale | 12′ to 54′ |
| 60. | *Willow Creek coal bed (C)* | 3′ 6″ to 1′ |
| 61. | Sandstone and shale | 76′ to 100′ |
| 62. | *Trinidad coal bed (B)* | 16′ 6″ to 1′ |
| 63. | Sandstone and shale | 20′ to 45′ |
| 64. | *Dillon coal bed (A)* | 16′ 6″ to 1′ |
| 65. | Shale | 1′ to 10′ |
| 66. | Halymenites sandstone | 50′ to 80′ |
| 67. | Shale and sandstone | 70′ |

The total thickness of this group is not far from 1,800 feet. The intervals between the coal beds vary greatly and the beds themselves are subject to sudden and unsatisfactory variations both in thickness and character. Some variations in the intervals may be found inexact, as aneroid barometers do not always act with absolute accuracy, but the most noteworthy variations occur within short distances and under circumstances which render error in identification of the beds almost impossible. Details respecting the several beds will be given in my report in the chapters devoted to local geology. It is necessary therefore to give in this place only a few notes respecting the more important members of the series.

The *Dillon coal bed* (*A*) is best shown on Dillon's Cañon, a tributary to the Canadian, where the bed has been worked. At one exposure in this cañon the bed shows—

*Coal*, 4″; shale, 20″; carb. shale, 16″; *coal*, 14″ clay, 1″; *coal*, 3′ 4″.

Thus giving 4′ 6″ of coal in one available bench. At another exposure the same bed shows two benches of coal, but the coal, though greater in quantity, is not so advantageously disposed as the other exposure. This bed is thoroughly persistent as a large bed, though it is not unfrequently worthless and degenerates into carbonaceous shale.

The *Trinidad coal bed* attains its greatest importance in the neighborhood of Trinidad, Col., where it is mined by the Denver and Rio Grande Railway Company for shipment and by others for local use. It has been opened near Raton Pass, directly under the Raton anticlinal, by the Scandinavian Company, for shipment. At Trinidad it shows seven divisions of *coal* and shale or clay, with a total thickness of somewhat more than 19 feet. But the refuse layers thicken rapidly southward, so that, at an exposure, say three miles from Trinidad, the same seven divisions are shown, but the thickness has increased to 54′ 8″, while at the Scandinavian Company's mines the thickness is 66′ 6″. The important part of the bed is the fifth division, which shows 5′ 5″ of coal at the Rio Grande mines, 6′ at the exposure on Raton Creek, and 9′ 6″ at the Scandinavian Company's mines. The other benches of coal show a similar thickening, and the total of coal in the several measurements is 7′, 6′ 10″, 10′ 10″, and 19′ 6″, the last being at the mines of the Scandinavian Company.

The coal from this bed is excellent for gas making, and it is shipped for that purpose to the large cities of Colorado. The "slack" is coked near Trinidad in beehive ovens, and the coke finds a ready market in the mining regions of Colorado, where it has displaced that from Connellsville, Pa.

Of the other coal beds, those lettered D, E, F, J, M, Q, R, and U are locally important, but their variations are so great that they need not be discussed here. The variations in gross thickness are due in many cases to thickening of the refuse layers.

The sandstones of the group are usually fine-grained, yellowish gray and massive, but these, like the coal beds, are liable to great variations, and only those overlying *coal beds* F, G, H, with those at the top and base of the series, can be regarded as altogether persistent. Irregular layers of limestone occur in several of the sandstones as far up in the section as the *Long's Cañon coal bed*. In these the rock is blue on fresh surface, but, being ferruginous, weathers yellow. No animal remains were observed in the higher rocks, aside from indistinct impressions of a *cardium*, apparently the same with the one which occurs in the *Halymenites* sandstone at the base of the group. But in all the flaggy layers of the sandstones impressions of leaves are numerous.

The *Halymenites* sandstone is so named because it is characterized by great abundance of *Halymenites major*, a fossil not found higher up in the series at any but one locality. The sandstone is gray to yellowish gray, moderately coarse in grain, holding some pockets of conglomerate, and everywhere, except in Dillon's Cañon, showing vast numbers of the nodose fucoid, from which I have given the name. It passes downward into the brownish shales and sandstones, which in turn merge almost imperceptibly into the shales of the Fort Pierre Group below.

## TERTIARY AND QUATERNARY AREAS.

The distinction between the Tertiary and the Quatenary has not been determined for this district, and much work still remains to be done before I can assert what should be regarded as Tertiary and what should be classed as Quatenary.

On the Canadian plains and on the mesas within the area of the Mora River, one frequently sees a chalky marl immediately underlying the thin recent deposit covering the plains. This has a travertin-like structure and, as far as ascertained, contains no fossils. It occupies depressions in the Dakota sandstone; at least, it was observed only under such circumstances at the south, but it is present over a so great extent of country that its existence cannot be due to any merely local causes. A similar tufaceous deposit occurs along the South Platte River as far as Greeley, where it underlies the superficial deposit as it does between the Mora and the Canadian Rivers. It is hoped that during the coming season the real relation of this limestone to the Santa Fé marls will be ascertained.

A curious conglomerate occurs along the west face of the Culebra Range from Costilla Creek northward to beyond Fort Garland. It begins at the plains and reaches up into the mountain gorges, forming a series of brownish-red foot-hills, rising in the highest to 10,000 feet above tide. These gravels are of comparatively recent origin, for they rest on basalt which flowed over the region at a very late period in the Tertiary; so that they must date from very near the close of the Tertiary or from the beginning of the Quaternary.

Further south along the range, these gravels or somewhat similar ones were observed far up in the mountains at the head of Ferdinand Creek and along the various forks of Frijole Creek, streams flowing to the Rio Grande through Taos Creek. Along the north fork of Ferdinand Creek the gravels are stratified and are composed wholly of *débris* from volcanic rocks, including even the latest of the basalts. Some of the layers are fine-grained, while others are conglomerate with great pebbles. On the south fork of Ferdinand Creek, as well as on the forks of Frijole Creek and on Junta Creek further south, the *débris* seems to contain only material derived from the Archean and Carboniferous. On both streams the accumulation reaches to more than 9,000 feet above the sea.

By some geologists these gravels have been referred to lake deposits. In several localities there can be no doubt that such was their origin; but in several other localities there seems to be almost equal certainty that they owe their origin to some other agency. This question will be carefully examined during the coming season.

## THE ERUPTIVE AREAS.

A large part of the district is covered by rocks of igneous origin, and a collection was made which illustrates fairly well the varieties observed.

A basalt sheet covers the Raton Plateau, and reaches down into the valleys within the plateau, as well as into the plains hundreds of feet below the top of the plateau. This is but part of a great basaltic area, stretching eastward beyond the limits of the district.

The second great area of basalt is on the Ocate mesa. It extends southward from the cañon of Rayado Creek almost to Fort Union. It stretches westward from the Canadian plains to Coyote Creek, whose valley at one time was filled by the flow. Outliers of this area are seen in the Canadian Hills.

A third area is at the southern extremity of the Turkey Mountains, near Fort Union. This is but of limited extent, and includes at present little more than the volcano at the edge of the mountains. But a stream of basalt flowed from this volcano down an arroyo to the cañon of the Mora River, thence along the cañon to its junction with that of the Canadian River, and backed up in the latter cañon for fully three miles.

Much of this basalt issued in the form of massive eruptions. Dikes are numerous in the Raton area, and some were seen west from Raton Pass in the Lignitic area, many of them occurring as sheets intercalated between the strata of the Laramie Group. But not all of the basalt was poured out in this way. Three volcanic cones remain in the Raton area, on the Capulin Vegas, at only six or seven miles beyond the eastern edge of the district. They are known as the "Mountains with Holes in the Top." A volcano existed on the Ocate mesa, whose cone still preserves its form. But in all probability only a small part of the basalt covering the Ocate mesa and filling up most of the old valleys within that space issued from this volcano. It is altogether probable, however, that the Turkey Mountain volcano was the source of most, if not all, of the basalt poured out in that part of the district, for no traces of the rock exist except in direct lines of flow from that crater.

Light colored lavas of earlier date prevail in the mountainous area, though a great basalt overflow covers much of the western slope of Culebra Range, and reaches across the Rio Grande Valley. The western slope of the Taos Range, as far as could be ascertained during a hasty examination at the close of the season, is covered by eruptive rocks, basalts, trachytes, and rhyolytes; but no detailed examinations were made there.

Enormous dikes of trachyte were seen on Costilla, Comanche, and Moreno Creeks. Patches of the same rock were observed on the east slope of the Culebra Range near the head of Vermejo Creek, and a small patch within the Laramie area stretches from the south fork of the Purgatory River to Vermejo Creek. But the great body of trachytic rocks centers in the Old Baldy Mountains at the headwaters of the several streams forming Cimarron Creek. Two great dikes are shown in the upper cañon of that creek. The overflow from these forms the mass of Old and Little Baldy and covers the high mountains between Cimarron and Rayado Creeks. Many dikes extend northward from this center into the Laramie area and into the narrow park following the east base of the Culebra Range. Costilla Peak is a fragment of an overflow belonging to this group, as also is Bare Cone, near by.

The study of the rock collections has not been completed.

## SURFACE GEOLOGY.

Many important facts have been gathered with reference to [the surface geology of the district; but a synopsis of them cannot well be made, and I must defer any statement respecting them until the full discussion can be given.

### ECONOMIC GEOLOGY.

As directed by you, I have made careful notes respecting the capabilities of the region for settlement, including under this head the distribution of timber, grazing and farming land. These matters will be discussed in the final report.

No important mines of gold or silver were seen. Fine placer gold mines exist in the Moreno Valley, and quartz mining for gold has been carried on extensively along the east side of Old Baldy. But both the quartz and the placer mines have become unimportant, the former through failure of the ore deposits and the latter through failure of the water-supply.

Abandoned quartz mines are reported as occurring on Colorado Creek, but no examinations could be made there, for when the locality was reached, the rocks were deeply buried under snow, and the season's work was practically closed.

## APPENDIX K (SUB).

### PRELIMINARY REPORT OF A SPECIAL GEOLOGICAL PARTY OPERATING IN COLORADO AND NEW MEXICO, FIELD SEASON OF 1879, BY PROF. JOHN J. STEVENSON, ASSISTANT.

UNIVERSITY, NEW YORK CITY,
*August* 15, 1879.

SIR: I desire to submit the following supplementary report:

In order that some gaps in the work of 1878 might be filled, a party was prepared for me at Fort Garland, which entered the field on May 20, 1879, and was disbanded on its arrival at Fort Union on June 24. Very material favors were received at Fort Garland, Fort Union, and Santa Fé, whereby the brief season was rendered a profitable one, and many thanks are due to the officers at those posts.

The route followed led from Fort Garland to Fort Union by way of the Red River Pass, from Fort Union to Santa Fé by way of Galisteo, and thence to Fort Union by way of the old Santa Fé trail and Las Vegas.

In accordance with your instructions, the economic interests of the region were carefully studied, and these will be fully discussed in the final report. The mines of the Placer Mountains and of Los Cerillos, both in the vicinity of Galisteo Creek, were visited. The former are now as they were when visited by Dr. Wislizenus thirty years ago, and very little work is done. The water supply is uncertain, and at best is too limited to permit the mines to become of great importance. The latter are still too new and undeveloped to permit one to speak positively respecting their future. At the same time it will not be amiss to say that the developments thus far are comparatively insignificant and by no means such as the newspaper accounts had led me to expect. The indications at the time the region was examined were quite indifferent, and the old Spanish mines were far from being so extensive as the ordinary reports allege.

Detailed examinations were made to ascertain the geology of the Galisteo area, where an unexpectedly complicated structure was discovered; but it is hoped that the result of this investigation will be to remove much of the uncertainty which has prevailed respecting the relations of the groups.

The study of the complicated trough between the Cimarron and Mora axes, designated in the report as the Coyote synclinal, has been completed, and numerous cross-sections have been obtained, which will serve to exhibit its peculiar features. Additional information was procured which will lead to a modification of the views expressed in the report respecting the extent of the Cimarron anticlinal. The general structure of the mountain area has been worked out and the relations of the axes are clear.

The relations of a huge mass of rocks underlying the Colorado shales and consisting of two great sandstone groups separated by a group of shale are somewhat obscure. The lower and the middle portions have been regarded as Triassic or as Jura-Trias by those who have preceded me in the study of this region; but for reasons to be given in the final report it may be best for the present at least to include the whole series in one and to apply to it the name *Dakota*. The group may be divided into the Upper, Middle, and Lower Dakota, and for the present it may be regarded as belonging wholly to the Cretaceous. At the same time this reference to the Cretaceous must be regarded as provisional, for a positive reference is not justifiable in the absence of fossils with definite relations.

Unfortunately time did not permit any examination of the west slope of the Santa Fé Range, and the western limit of Archean there is conjectural.

Very respectfully, yours,

J. J. STEVENSON.

Capt. GEORGE M. WHEELER,
*In charge.*

## APPENDIX L.

### ORNITHOLOGICAL REPORT FROM OBSERVATIONS AND COLLECTIONS MADE IN PORTIONS OF CALIFORNIA, NEVADA, AND OREGON, BY ASSISTANT H. W. HENSHAW.

UNITED STATES ENGINEER OFFICE,
GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN,
*Washington, D. C., April 21, 1879.*

SIR: I have the honor to transmit the following report upon the ornithology of the regions visited by me during the field seasons of 1877 and 1878.

Very respectfully, your obedient servant,

H. W. HENSHAW.

Capt. GEORGE M. WHEELER, U. S. A.,
*Corps of Engineers, in charge.*

The present report includes an enumeration of the birds met with during the field seasons of 1877 and 1878 by the writer, with more or less extended notices of their habits, relative abundance or scarcity, extent of habitat, &c., &c., from original field-notes and observations. To but a limited extent has it been thought advisable to depart from the rule of including only results accruing directly from the expedition, and to indicate briefly general facts respecting the distribution of species elsewhere, as compared with the region under consideration. In the instance of a number of the puzzling forms met with, a careful study has been made of their relations with allied species and the results included in the present connection; but in the main the notes bear directly upon the area included in the examinations of the survey for the time specified.

In 1877, field-work in connection with Party No. 1, California Section, extended from the 12th of May to the 1st of October. The following year and with the same party, the interval between July 18 and October 1 constituted the field season. Unfortunately in the latter year work began at so late date that the much desired opportunity was lost of presenting in the present report a full account of the very considerable number of species inhabiting this region, of whose nesting habits little or nothing is known. The notes therefore that bear upon this part of the birds' histories were obtained during the early portion of but a single season.

The routes followed during the two years amounted practically to a continuous line from Carson, near the western border of Nevada and a little south of the Central Pacific Railroad, to The Dalles, on the Columbia River. A considerable portion of the time was spent in the mountains, but more in the valleys and on the plains that lie at their eastern bases. Thus opportunity was had, so far as the necessities of the topographical parties to which the writer has usually been attached would permit, to make a comparative study of the birds of the several sections entered. Taken in connection with what has hitherto been accomplished in the same region, and especially with the very valuable report of Dr. J. C. Newberry, made in 1855, it is thought that the avifauna of the eastern slope, in its general features, may be considered as pretty well made out. Perhaps a brief glance at the area covered in the present report, in its relations to contiguous regions, may be of interest.

The Sierra Nevada of California, in its entire length, and the Cascade Mountains of Oregon form essentially a continuous chain of peaks, which constitutes the first real obstacle to the extension of animals and plants to the westward that is encountered after the main chain of the Rocky Mountains, the "backbone" of the continent, has been passed. So far, at least, as the extension of birds is concerned, it appears to be an extremely effectual one, and the rocky barrier thus constituted may be taken as limiting with precision the Middle Faunal Province.

Attention has elsewhere* been called to the fact that the influence of the Pacific province is visible in the birds of the eastern slope, and the conclusion drawn from a study of its avian life, that, while by no means a typical portion of that province, it is yet sufficiently dashed by Pacific province forms as to more properly be included in that zoological division rather than with the middle region. The number of species and varieties of birds typically representing the Pacific province that are found along the eastern slope is not very great, since, of course, they are limited to mountain-inhabiting forms that constitute but a small proportion of the aggregate number belonging thereto. On the other hand I know of but four species strictly attributable to the middle region that reach into the mountains of the eastern slope, viz, *Turdus pallasi auduboni*, *Carpodacus cassini*, *Pica melanoleuca hudsonica*, and *Tetrao obscurus*. That the number should be so small seems at first thought strange, when it is remembered that the low elevations just east of the mountains are unmistakably middle province in the character of their avifauna.

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* Annual Report of Geographical Surveys West of the One Hundredth Meridian, 1877, p. 1304 *et seq*

With reference to the geological structure of the Deschutes Basin and other areas just east of the Sierra and Cascade Ranges, Dr. Newberry affirms their intimate connection with the Rocky Mountain Desert; nor in considering the flora and fauna of these areas does he fail to note many examples that serve to indicate their closer affinity to the Rocky Mountain region than to the Pacific.

In the case of birds the physical obstacles to be surmounted, formed by the high mountain crests, although doubtless not without effect, have probably far less to do with the absolute limitation of species than has the check offered by the conditions of a different climate, with the consequent change in plant and insect life which this implies. The region west of the mountains has a large mean annual rainfall, the effect of which upon plant and animal life is further maintained during the dry season by the accession of moisture from the ocean; but the moisture-laden winds are finally robbed as they pass eastward over the summits of the mountains, and they reach the distant interior dry and without life-giving power. As a consequence, and in connection with its volcanic character, the interior plateau country, almost rainless during the summer, is, for the most part, dry and barren in the extreme. The oases, in fact, in this general desert are limited to the areas which, through geological disturbances, have been uplifted to a sufficient height to intercept cloud moisture; and, in addition, the banks of the streams, which afford restricted ground for the growth of vegetation, and through it a home for animal life. With the above well-defined differences of climate, it is not surprising that a corresponding change in the flora and fauna of the two regions is observable.

Although, as stated, the Sierra and Cascade Ranges present in the main a continuous chain, its continuity is interrupted in several places, the Columbia, the Klamath, and the Pitt Rivers breaking through its wall in their progress to the Pacific. Nevertheless, the presence of the natural passes thus afforded does not appear to have a marked effect upon the distribution of birds and mammals, if, indeed, it is to be detected at all. The narrowness of their cañons, flanked as they are in the case of the Columbia by extremely dense coniferous woods, and of the others by an inhospitable desert-like country, would probably have an effect in preventing the passage of species back and forth, were there no other existing cause. But, as remarked before, probably the main obstacle is to be found in the different climates of the two regions. Those species habituated to the warmer, more equable, and moist climate of the Pacific side, and to a country covered with profuse vegetation, would naturally be repelled by the harsher climate and dry, desolate country to the eastward; while such as are inured to the latter conditions would find the former equally unattractive. As further evidence that it is chiefly the climate and the conditions resulting therefrom that limit the range of birds, and not the mere physical barriers offered by mountain chains, it may be remarked that by no means the same amount of difference is to be observed between the birds of the regions that lie contiguous to the eastern and western slopes of the Rocky Mountains that is to be noted here. And we may safely infer that the very marked faunal similarity of the latter sections is largely due to the corresponding similarity of climates, the Rocky Mountains appearing to have little or no effect in limiting the range of birds and mammals.

In a region possessing the forbidding aspect of that to the east of the Sierras, it might be inferred that the sum total of bird life would be rather small. In general, this is true; but along the streams there is usually to be noticed a rather marked concentration of species, while in some favored localities the number also of individuals is great. The mountainous districts, with their heavy growth of conifers and deciduous shrubs, as well as their profusion of annual plants, which up to a certain limit accompany the increased amount of rainfall, form the home of numerous species not found elsewhere. In fact, the more favorable localities in the mountains form the best collecting grounds for the naturalist.

A somewhat special type of country was entered during the past season in the Deschutes River region, the general watershed of which stream has elsewhere been termed the "Deschutes Basin." As it is peculiar in some of its aspects, this region merits brief mention. With a general elevation of about 4,000 feet above sea-level, much of this area is covered by a uniform growth of the yellow pine (*Pinus ponderosa*), which appears to thrive wonderfully well in the light soil of pulverized pumice. From the fact that the water supply is extremely limited and occurs for the most part only as small springs or in water-holes, very few shrubs and plants are able to maintain existence, and a hardy kind of grass alone covers the soil with a scanty growth. So far as birds are concerned, it would be difficult to realize a more complete type of desert than is here presented. For days in succession, I have ridden through these forests, the mules each step sinking above the fetlock in the treacherous dust, which, rising in clouds, marked the route of the party as by a column of smoke, scarcely seeing or hearing a bird. The rare note of a woodpecker or nuthatch, or the chirpings of a few venturesome snowbirds, alone broke the silence of the woods. Even along the banks of the Deschutes there was noticeable at the time of my visit, in September, a remarkable poverty of birds. This I attributed, in the lack of other apparent causes, to the fact that the shrubbery of its banks consisted only of willows, while a heavy growth of coarse grass replaced the bright flowers and varied vegetation of higher altitudes.

Notable as are these forest deserts for absence of bird-life, they yet form the home for thousands of mule-deer and antelope. The former, although generally dispersed, center in greater numbers in certain spots, which are regulated probably by their accessibility to water, and not a day passed without many being started by our train.

The mule-deer, as nearly as we could learn, reaches only into the mountains of the eastern slope, and does not pass the summit; a somewhat singular fact in regard to its distribution, since it reaches quite to the coast in the region south of San Francisco. To the west, in Northern California and Oregon, it is replaced by the Pacific black-tailed deer (*C. columbianus*). This animal, while in the main confined to the region west of the mountains, was ascertained to cross the range at a number of points and inhabit the same sections as the *C. macrotis*. This, however, is the exception rather than the rule, the eastern slope, as a rule, appearing to be free from its presence.

Along the Dechutes River we met with the white-tailed deer, the so-called *C. leucurus*. In comparison with the mule-deer it was not numerous, and its range appeared to be confined to the river-bottom and to the forest closely adjacent.

The antelope, typically an animal of the open grassy plains, concentrates more in the "deadenings," which are often of many hundred acres in extent, or live in the sections where the pines dwindle away and are replaced by a growth of cedar. Still, they were not infrequently met with in the pine woods, their haunts here thus furnishing a strong contrast to the usual home of the species further east.

In connection with my work, my grateful thanks are due for the many courtesies and very material assistance rendered by my friend Mr. H. G. Parker, of Carson, Nev. I am also greatly indebted to Maj. J. M. Norvall, at the time of my visit in command of Camp Bidwell, for the generous hospitality received at his hands. During my stay with him every possible aid to my investigations was freely extended. I would also gratefully mention the aid received from my friend Mr. Robert Ridgway, of the Smithsonian Institution, in the shape of facilities extended in connection with the study of specimens, as also for many valuable suggestions.

## TURDIDÆ—Thrushes.

### TURDUS Linnæus.

*T. migratorius propinquus* Ridgw. Western Robin.

This variety of the common robin is found throughout this whole region as a summer visitant, and is more or less abundant according to special locality. In Nevada, the bulk of individuals arrive from the south in March, and spend the early spring in the low and sheltered valleys. As summer advances they make their way higher and higher up on the mountain sides, where they inhabit preferably the aspen groves. The species begins to lay in the neighborhood of Carson about the middle of May. A considerable number of pairs rear their first broods here and in other similar low valleys. But as soon as the young are on the wing all withdraw, apparently to the mountains, and by July, when the lowlands are dry and parched, the sight of a robin is extremely unusual.

Robins were fairly numerous in Oregon, along the Columbia River, during the last of October, and a few doubtless winter even at this high latitude.

*T. nævius* Gm. Varied Thrush; Oregon Thrush.

This fine thrush is chiefly known to us as it occurs during fall and winter at points far south of its summer home. Apparently its breeding range is wholly confined to the regions west of the Cascade, and perhaps the northern Sierra ranges, from a point somewhere about the Columbia River northward. Even in October I saw but a single individual at The Dalles, while a day's march down the Columbia toward the west slope of the Cascades brought me to where the species was very numerous.

From my friend Mr. H. G. Parker I have information of the occurrence of this thrush near Reno, in Western Nevada, just at the base of the Sierras, thus confirming its supposed presence here, as mentioned in a previous report (1877). Very large numbers made their appearance in this neighborhood about February 1, probably from the mountains to the westward, and remained till into March. Doubtless this is not an unusual event in the history of this species, and we may consider its winter habitat as including the main chain of the Sierras on either slope.

The four instances known of the occurrence of the varied thrush along the eastern coast must be looked upon as wholly exceptionable, especially as no cases are on record of its appearance even in the remoter western States to the east of the Sierras.

*Habits.*—As the result of my own observations I can add but few details respecting the habits of the varied thrush. In the fall it is not a bird of the open, but appears to pass most of the time in the dense evergreen woods, where it obtains from amongst the low shrubbery various kinds of berries, which evidently form its chief fare at this season. Under my observation it bore out its ascribed character of being a rather shy and suspicious bird, and it was only upon occasions that I succeeded in pushing my acquaintanceship to close quarters. While making my way along the innumerable old wood-roads and tangled bridle-paths that intersect the pineries in all directions—relics of the woodchopper and lumberman—unsuspected, I frequently came upon small flocks of these thrushes. The alarm-note is a single loud *chuck*, frequently repeated, and is very similar to that of the small olive-backed thrushes, but much louder. A very few moments upon such occasions sufficed to see the band dispersed in alarm, and each seeking a safe position towards the tops of the tall, thick firs and spruces, in which they invariably took shelter. Altogether there is much in the habits and notes of the species that is suggestive of the smaller members of the genus, and it certainly resembles them in more particulars than does the robin. Still its size, its gregarious disposition, and its partiality for berries, naturally cause it to be associated in thought with the robin.

I saw many nests in the crotches of the small firs and upon brushy saplings that, under casual notice, much resembled the usual structure of the robin, but some of which were probably constructed by the varied thrush. Not recalling to mind at the time how readily identifiable the nest of this species is—constructed without mud—I neglected to examine these structures critically. That more or less remain to breed in the dense forests along the Columbia seems in the highest degree probable, and, in fact, I was informed by lumbermen that both "robins" remained all summer.

*T. pallasi auduboni* (Baird). Audubon's Hermit Thrush:

During the past summer the important fact was ascertained that this form of the hermit thrush, instead of being strictly limited to the Rocky Mountains, as has hitherto been assumed, crosses the basin and breeds along the eastern slope of the Sierras. During the summer of 1877 I heard, in several of the subalpine valleys of Northeastern California, what were without doubt the Audubon's thrushes, but failed to secure specimens. Here they were evidently not very numerous; but in the mountains back of Camp Bidwell, the succeeding season, the same thrush was heard, and this time was satisfactorily identified by shooting the bird. They were here very abundant, and at this date, July 19, the pine woods were filled by the sweet music of the males.

*T. pallasi guttatus* Pall. Dwarf Hermit Thrush.

The dwarf thrush appears to occur along the eastern slope, as it does in the Rocky Mountains, only as a migrant, and as such perhaps only in the fall. By the last of August it was found numerous along the foot-hills of the Cascade Range of Oregon.

I consider it very probable that the southern breeding limit of this form will eventually be found to include the mountains of Oregon, upon their western slope; but we have no facts of observation to fully bear out such a conjecture.

## MYIADESTINÆ—Fly-catching Thrushes.

### MYIADESTES Swainson.

*M. townsendi* (Aud.). Townsend's Fly-catching Thrush.

This bird was found by our party to be very abundant in the Deschutes Basin in September, where, too, it was reported by Dr. Newberry in 1860. In fact, I have never seen the bird congregated in such numbers over so wide an area as here. In fall and winter it appears to be generally dispersed over much of the country adjoining the eastern slope, where in summer it appears to be almost entirely absent. During the summer of 1877 I saw but a single individual in the mountains of Eastern California, although the condition of this individual, a male, indicated that it was mated and breeding, so that it is to be presumed that the multitudes that throng here in fall localize themselves in some favorable section during the breeding period.

The localities affected by them in Oregon in fall are almost exactly similar to their range in New Mexico, Utah, &c., a fact which sufficiently establishes their natural predilections. It is as desolate a type of country as one can well imagine, being covered everywhere with volcanic *débris*, which is thrown up in the shape of low hills or scattered broadcast over the general expanse as though the unsightly blocks had rained down. Ravines with their rocky ridges scar and seam the country in every direction, while an almost total absence of vegetation, except in the shape of dwarf cedars or stunted piñons, renders such a region a desert indeed. Of such a nature is the country to the south and west of Prineville, Oregon, and here a day's march along the road revealed many hundreds of these fly-catching thrushes.

It is a curious fact in the history of this species that, in the fall, when the season of love, which is supposed to directly inspire the music of birds, has long since passed, and most other songsters are either entirely silent or their songs are limited to the first rude practicings of the young males, the Townsend's flycatcher should now—not at rare intervals, but as a regular habit—give utterance to snatches of melody that, though but a fraction of its splendid powers, may yet challenge the utmost efforts at emulation of most other species. And I am by no means sure that such musical rivalry as takes place at this time among the males does not owe its origin, in part at least, to the fading embers of a passion not yet fully spent. At all events, I have often seen, at this season, two males in eager pursuit of a companion—apparently some coy female—that led them an eager chase for five or ten minutes at a time, in a way that could suggest only the ardor of the mating season. The males engaged in such a chase are always full of song, which pours out as brilliant snatches and fragments of their fuller, more perfect symphonies of spring.

### OROSCOPTES Baird.

*O. montanus* (Towns.). Sage-Thrasher.

Nowhere in the wide region inhabited by this thrush is it more abundant than on the sage-covered hills and plains of Western Nevada, just at the base of the mountains which shut off the western extension of the species.

In a climate like that of Nevada, where the transition period from spring to summer is never very well marked, and summer is at hand almost as soon as the snow disappears, there are always to be observed great irregularities in the time of nesting of the birds. This is as true of the smaller as of the larger species. Thus, taking the present bird as an example, the 20th of May appears to be just about the height of its breeding season. Although at this time not a few pairs were feeding full broods, yet the majority of the nests contained fresh eggs, while some dilatory couples had but just brought their homes to completion. There was thus to be noted a difference of fully six weeks between the earliest and latest periods of deposition of the first clutches of eggs.

As the eye passes over the sage plains of the far West it finds a broad, slightly undulatory expanse, covered everywhere with the characteristic sage-brush and presenting to the sight no breaks in its apparently smooth surface. In reality, however, the plains are very far from being level, and it needs but a short walk in any direction to reveal the presence of unsuspected little valleys and ravines, their boundaries traced on either side by more or less abrupt rocky ridges. It is along the crests and sides of just such ridges that the sage-thrasher is most at home, and in the vernal season, at intervals of every few hundred yards, the males may be heard pouring out at all times of day their delightfully melodious strains. In the presence of its humble associates, the Bell's finch and Brewer's sparrow, which alone share its desolate surroundings, our thrush finds no rivalry to stimulate its efforts; but, unmindful of this, it sings on, finding, perhaps, its reward in the satisfaction born of its own powers or the delight its strains carry to the heart of its silent brooding mate. Its song, though not possessed of great variety, is noteworthy for its sweetness and expression.

The nests, of which I have examined very many, vary but little either in composition or situation. Solidity and bulkiness sum up their chief characteristics. The foundation is of sticks and twigs, the thorny character of which enables them to be firmly interlocked, so as to form a strong support capable of resisting all ordinary accidents, and even to defy wind and weather for many successive seasons. I do not think, however, they are ever utilized a second time. The inner or nest proper is made of rootlets, with perhaps a few horse-hairs, which are woven into a circular depressed cup.

Numerous sets of eggs compared together show but little variation, and this chiefly in the amount and method of distribution of the spotting rather than in the colors themselves.

## SAXICOLIDÆ—Stone Chats.

### SIALIA Swainson.

*S. mexicana* Sw. Mexican Bluebird; Chestnut-back Bluebird.

This is the common bluebird of the region. During the summer it inhabits not only the low valleys, but, to even a greater extent, the mountains, being there found in the dense pine timber up to about 6,000 feet. As is the usual custom of the Eastern species, the present bird, as indeed also the Arctic, raises two broods during the summer, and the season is far advanced ere family duties cease.

*S. arctica* Sw. Arctic Bluebird.

The habitat of the present bird is, in general, more northern than that of the preceding. Nevertheless, the two species are not infrequently marked in local lists as inhabiting the same districts at the same season. When such is the case, the present species is usually found at higher altitudes in the mountains, whence it descends in fall and winter to the same neighborhood where the chestnut-back bluebird makes its summer home. Their connection is hence not so intimate as might naturally be inferred.

The statement of a more northerly habitat for the Arctic bluebird is true only in part; since, while it attains higher latitudes and, coincident with this, seeks out higher elevations in the mountains, it yet was found breeding by our parties as far south as Santa Fé, and here, too, entirely outside of the mountains. This probably represents about its southern breeding limit, while, on the other hand, *mexicana* does not reach much farther south.

A nest of *arctica*, probably the second of the season, was found July 31 in a dead pine stub. It contained five eggs, far advanced.

## CINCLIDÆ—Water Ouzels.

### CINCLUS Swainson.

*C. mexicanus* Sw. American Dipper.

Common upon many of the streams of the eastern slope, where noted as high up as the Columbia River.

Concerning the habits of this interesting species, I have no new facts to add to the extended notices which have appeared elsewhere, more particularly as they seem to be everywhere about the same. In reading Macgillivray's excellent account of the European dipper and its mode of life, I notice a statement to the effect that the dipper is by no means an adept at walking on land; he says, after denying its alleged absurd habit of walking in the water on the bottom: "Even on land I have never seen it move more than a few steps, which it accomplished by a kind of leaping motion. Its short legs and curved claws are very ill-adapted for running." * * * Such being the case, it would appear as though there is, in this particular, a very marked difference between the European bird and our own; for no one who has made the acquaintance of our dipper in its native haunts would hesitate for a moment to affirm that it is both agile and graceful in its movements on land, if grace be understood to mean an easy and assured manner. Possessed apparently of equal powers for progression under water with its European ally, our species by no means depends wholly, or at times even in great part, upon these for its subsistence; but, on the contrary, may often be seen for an hour at a time wading in the shallows, or running quickly over the wet rocks or along the pebbly shores in search of food, when its activity and nimbleness of movement are very apparent. In fact, its amphibious nature would appear at times to be almost forgotten, or to be called to its aid only for very brief intervals; while, again, it appears on land, only to disappear a moment later in the swiftly moving current.

## SYLVIIDÆ—True Warblers.

### REGULUS Cuvier.

*R. calendula* L. Ruby-crowned Kinglet.

A common summer inhabitant of the pineries. Its songs, loud, clear, and harmonious, were heard all day long issuing from the tall, thickly-foliaged firs and spruces, in which, without doubt, the nests were secreted.

## CERTHIIDÆ—Creepers.

### CERTHIA Linnæus.

*C. familiaris* L. Brown Creeper.

A common summer inhabitant of the coniferous belt all along the eastern slope.

## TROGLODYTIDÆ—Wrens.

### SALPINCTES Cabanis.

*S. obsoletus* Say. Rock Wren.

A common summer visitant throughout this whole region. Its love for rocky fastnesses is well typified in its name. Its nest is often placed beneath the shelter of a rock, or, as I have on several occasions seen it, in some slight recess or natural cavity in a sand-bank; in fact, any hidden nook or natural recess that promises concealment is available for its purpose. A nest found on the 15th of May contained eight eggs, the young in which were just ready to chip the shell. The rock wren is thus among the very first of the small birds to lay. The eggs vary so little as to be easily characteristic of the species; ground-color pure white, with a rather even distribution over the entire surface of minute, roundish, reddish-brown spots.

### TROGLODYTES Vieillot.

*T. ædon parkmanni* Aud. Western House Wren.

Numerous as a summer resident all along the eastern slope. As a rule, keeps in the timber of the uncivilized districts, and seems rather loth to accept the accommodations offered in the towns, where, however, it is occasionally seen.

*T. hyemalis pacificus* Bd. Western Winter Wren.

This bird was not met with until the Columbia River was reached; here in October it was found to be very abundant, more so, in fact, than I have ever known the winter wren to be elsewhere. Nearly every brush-heap contained at least one of these sputtering, scolding mites, while not rarely several were heard or seen in the space of a few yards. It was found on both slopes of the Cascades, although it was not nearly so numerous upon the east side of the mountains as upon the west. As fall advances, it finds its way farther south, and reaches on both slopes as low as the latitude of San Francisco. I am inclined to believe that it breeds all through the pine woods of the mountains near the Columbia. It winters here, as also, according to Cooper, in Washington Territory.

### CISTOTHORUS Baird.

*C. palustris* Wils. Long-billed Marsh Wre

Extremely abundant in all the tule marshes.

## PARIDÆ—Titmice.

### LOPHOPHANES Kaup.

*L. inornatus* (Gamb.). Plain Titmouse.

This species is present in Nevada in the foot-hills of the mountains and on the low ranges to the east of the main chain. It was not met with in the Columbia River region, nor even in Northern California.

### PARUS Linnæus.

*P. rufescens* Towns. Chestnut-back Chickadee.

According to Dr. Cooper, this species is the most abundant of the family in Washington Territory, where, however, it is probably limited for the most part or entirely to the districts west of the mountains. Such, at least, appears to be the case in Oregon, where the species did not fall under my observation until at the Cascades on the western slope, where I saw a single small flock in October. It is probably a summer resident here, and perhaps even farther south in Northern California. In fall it migrates to below San Francisco, but does not appear upon the eastern side of the chain.

*P. montanus* Gamb. Mountain Chickadee.

Breeds numerously among the pines. Extremely abundant among the oaks of the eastern slope, near the Columbia River.

### PSALTRIPARUS Bonaparte.

*P. plumbeus* Bd. Plumbeous Titmouse.

This chickadee, which is peculiar to the middle province, extends its range clear to the foot-hills of the Sierras, but does not enter the mountains. Thus, among the barren piñon hills near Carson City, I saw, in July, a flock of twenty or thirty individuals.

## SITTIDÆ—Nuthatches.

### SITTA Linnæus.

*S. canadensis* L. Red-bellied Nuthatch.

This species appears so much oftener in the local lists of the Eastern States than of the Western that many ornithologists have come to regard it as a quite typically eastern species. Nevertheless, in the extreme parts of the West, as upon both sides of the Sierras, from the line of the railroad to the Columbia River, and so on to the north, the red-bellied nuthatch is really a common bird, and in much of this area it doubtless breeds. It appears to be the presence of a country suitably timbered to meet its wants—pine-lover as this species pre-eminently is—more than aught else that determines its presence or absence. In addition, its distribution is clearly governed by its preference for a cool climate, such as it finds in the north or in the high Sierra Nevada.

Towards the Columbia River it was observed to become more numerous, and upon the upper Deschutes its numbers, in certain localities, were comparable with those of the pigmy nuthatch.

*S. carolinensis aculeata* (Cass). Slender-billed Nuthatch.

A numerous and constant resident among the conifers; not so common towards the Columbia River as either of the other species.

*S. pygmæa* Vig. Pigmy Nuthatch.

The most numerous of the family in the Sierra Nevada and Cascade Mountains, as almost everywhere through the West.

### SYLVICOLIDÆ—American Warblers.

#### HELMINTHOPHAGA Cabanis.

*H. celata lutescens* Ridgw. Western Orange-crowned Warbler.

Moderately common in summer when inhabiting the mountain slopes, but most numerous during the fall migration.

#### DENDRŒCA Gray.

*D. æstiva* (Gm.). Yellow Warbler.

Numerous as a summer resident in the shrubbery of the streams, which the species follows up to an elevation among the mountains of at least 8,000 feet. It penetrates beyond the Columbia and into Washington Territory.

*D. townsendi* Nutt. Townsend's Warbler.

This bird, which I had hoped, though scarcely expected, to find a common resident of the coniferous belt of the Cascades in Oregon, was met with but twice, in September. In each instance the individual was migrating in company with flocks of Audubon's warblers and other birds.

In full plumage the Townsend's warbler is one of the most beautiful of the family, as it has been until a comparative recent period one of the rarest. Since it was found by the expedition of 1874 to be a common migrant in the mountains of Southeastern Arizona, numerous specimens have been received by the Smithsonian Institution from California, notably from near Sacramento, where obtained by Mr. L. Belding. This warbler appears to be only a casual migrant along the line of the eastern slope, and, in three seasons' collecting, the two mentioned above represent all I have seen. On the Pacific side, however, it is comparatively numerous, both in spring and fall. As to its breeding range, I can find no evidence on record that warrants the statement that the species finds a summer home within our territory. Still it would not be surprising were it eventually found to summer in Oregon, in the dense pine-belt to the west of the Cascade Mountains. If such is ascertained to be the case, this, at least, is likely to prove its extreme southern limit. The fact that the statements of its occurrence in the United States have always been accompanied by the term "migrant," affords pretty conclusive proof that as a species it summers in the far north.

Such migrants as are found in the Rocky Mountains in fall, at which season they alone, have been noted, are to be reasonably accounted for as having followed this path from the extreme northern points of that range, where it approaches the Pacific.

*D. auduboni* (Towns.). Audubon's Warbler.

Common as a summer resident among the conifers at high elevations; most numerous during the migrations, being, in fact, the chief representative numerically of the *Sylvicolidæ* along the eastern slope.

#### GEOTHLYPIS Cabanis.

*G. trichas* L. Maryland Yellow-throat.

By no means uncommon in Western Nevada, in situations similar to those frequented by the species in the East. A nest found at Washoe Lake, Nevada, May 23, contained four eggs far advanced toward hatching.

*G. macgillivrayi* Bd. Macgillivray's Warbler.

Fairly numerous in summer along the eastern slope. I find no reference to the species in my note-book as occurring farther north than Northern California. As, however, according to Cooper and Suckley, it reaches to Puget Sound along the coast, it is safe to infer that on the eastern slope it passes the Columbia River into Washington Territory.

A nest found July 24 contained four young a few days old.

### ICTERIA Vieillot.

*I. virens longicauda* (Lawr.). Western Yellow-breasted Chat.

A rather common summer visitant about Carson, Nev., but becoming less so to the northward, until, in extreme Northern California, it is quite rare.

### MYIODIOCTES Audubon.

*M. pusillus* (Wils.). Wilson's Black Cap.

As a summer resident of the eastern slope the species appears to be rare; it may, however, be more common at this season towards the Columbia River than farther south.

June 24 I saw a female of this species in an alpine valley of Northern California, at an elevation of about 6,000 feet. Her excitement at my presence convinced me that her nest was near by; but circumstances not favoring a long search, I failed to discover it. In fall the species is comparatively common.

## TANAGRIDÆ—Tanagers.

### PYRANGA Vieillot.

*P. ludoviciana* Wils. Crimson-headed Tanager.

A common summer resident of the eastern slope as far to the north at least as the Columbia River, and without doubt reaching into Washington Territory.

## HIRUNDINIDÆ—Swallows.

### HIRUNDO Linnæus.

*H. erythrogastra* Bodd. Barn Swallow.

A numerous summer resident of the lowlands.

### TACHYCINETA Cabanis.

*T. bicolor* (V.). White-bellied Swallow.

This is a more or less abundant inhabitant of the eastern slope, according to circumstances. It was not met with farther north than Northern California. Here in the mountains near Camp Bidwell it was numerous enough the last of July, at which time the pairs all had young, as was shown by their frequent visits to woodpeckers' holes in the aspens.

*T. thalassina* (Sw.). Violet-green Swallow.

This is an extremely abundant summer visitant in certain portions of Eastern California and Western Nevada, as, for instance, at Pyramid Lake. The pyramid-like cliffs which give name to this body of water form the abode of thousands of these beautiful swallows, which resort to the niches and holes in the faces of the rock for nesting sites.

In the mountains, where it is also abundant, it selects for this purpose the deserted holes of woodpeckers, giving everywhere marked preference to those in oaks. It is almost always found in close proximity to water.

A nest found July 1 contained five young and two unfertile eggs.

### PETROCHELIDON Cabanis.

*P. lunifrons* (Say). Cliff Swallow.

By far the most abundant and generally distributed of the family.

### COTYLE Boie.

*C. riparia.* Bank Swallow.

Present in Nevada and Eastern California, but apparently less numerous than the following.

### STELGIDOPTERYX Baird.

*S. serripennis* (Aud.). Rough-winged Swallow.

According to Cooper and Suckley, this swallow occurs as far to the north on the coast as Puget Sound; certainly present along much of the eastern slope, and doubtless extending into Washington Territory along this line.

### PROGNE Boie.

*P. subis* (L.). Purple Martin.

Colonies encountered at numerous localities among the pine woods of the mountains, where they are quite local.

## VIREONIDÆ—Greenlets.

### VIREO Vieillot.

*V. gilvus swainsoni* Bd. Western Warbling Vireo.

This vireo was found to be present along the eastern slope as far north as Southern Oregon, and, as I have never seen it more abundant than it was in Northern California, I have no doubt that it reaches to the Columbia along this line, or even into Washington Territory, as it does, according to Cooper and Suckley, along the Pacific side.

Very little can be said of its habits here that would not be a repetition of published accounts of the Eastern warbling vireo. It is merely that bird transferred from its usual surroundings to the wild mountain districts of the west. In the mountains near Camp Bidwell, the locality alluded to above, where the species was so numerous, I found many nests, three or four being often met with during a morning's collecting. They were without exception built upon small aspen trees, from three to five feet above the ground. With a lining of fine grasses, they were composed mainly of long strips of white fibrous bark, festooned externally with spiders' webs, bits of cottony substances from plants, &c. At this date, July 20–30, the eggs were so far advanced as to render their preservation very difficult.

*Vireo solitarius cassini* Xantus. Cassin's Vireo.

Few birds have given rise to more perplexing doubt and uncertainty respecting their relationships than the Cassin's vireo. Founded by Xantus in 1859, upon a fall specimen from Fort Tejon, its subsequent written history has been full of vicissitudes; for while by some authors it has been accepted as a valid species, by others it has been affiliated with *solitarius* as a variety; or, again, has been rejected altogether, and thrown into the list of synonyms of the latter bird.

From the time I made the acquaintance of this vireo in the southern Rocky Mountains it has had a peculiar interest for me, more especially, perhaps, from the fact that while then, and upon the many subsequent occasions I have met with it, I have had not the slightest difficulty in properly identifying the recently killed specimens or even the live birds; yet, in the closet and upon comparison with other specimens from the West *marked as solitarius*, I have found it extremely difficult to draw a line between the two; in fact, until the present time I have never been able to arrive at any satisfactory conclusion respecting the true rank of *cassini* and its kinship to *solitarius*. I am now fully persuaded, and trust to be able to show, that *cassini* is at the least something more than a special plumage of *solitarius*, which was the opinion expressed by Professor Baird in his Review of North American Birds, when, it is to be remembered, the type-specimen represented all that was known of the supposed species, the absence of material for comparison doubtless having much to do in shaping this view. Since then there have accumulated in the Smithsonian, as the result of the collections of this expedition and from other sources, twelve or more specimens that are either like the original type of *cassini*, or so near it that their identity with it is beyond suspicion. It is perfectly safe to say that, whatever it is, they are.

With little or no difference in size from Eastern *solitarius*, the type—and it is to be remarked that certain of the recently obtained specimens not only share its peculiarities but even exhibit them to a greater degree—offers only differences of coloration. These may be briefly summed up as follows: Typical examples of *cassini* are very much duller than the corresponding plumages of *solitarius*. The head above and on the side, instead of being of a decided blue or bluish ash, presents little or absolutely no contrast to the olive-brown (instead of olive-green) of the dorsum. The lores and orbital ring, instead of being pure white, are of a dull white, strongly inclining to fulvous. The green of the sides is much mixed with or replaced by brown; the under parts generally are of an impure white, the result of a general admixture of brown. In fact, extreme examples of *cassini* are colored so much like *huttoni* that upon a color basis alone it would be difficult to distinguish them.

There are a sufficient number of specimens at hand showing the above characters to prove beyond a doubt that *cassini* is entitled to rank of some kind; in other words, that it is not a mere accidental plumage of *solitarius*. For be it noted, as stated by Professor Baird of the type, that *solitarius* as it is colored in the East never approaches the above. The color peculiarities of *cassini* are to be regarded then as entirely beyond and independent of individual variation. But, to complicate matters, nearly every author who has had occasion to treat of Western birds has noticed specimens, evidently not typical *cassini*, which he has referred with more or less doubt to *solitarius*. Thus, specimens of so-called *solitarius* are before us from Washington Territory, Oregon, California, Nevada, Utah, Wyoming, Arizona, &c. Some of these are certainly very close to *solitarius*, and I have always presumed the occurrence of that species in the West to be a matter that admitted of no doubt. But a recent careful examination of all these specimens shows not one that can fairly be called *typical* of that bird. In such specimens the back is of a varying shade of green; the head is more or less ashy in contrast, while the under parts are of a purer white than is the case with typical *cassini*. It is to be remarked, however, that not only is it scarcely possible to find two of these doubtful specimens that agree with each other, but by means of them a series can be formed that appears to grade directly from the typical *cassini* towards and almost, if not quite, into *solitarius*. The percentage of specimens of which the statement holds good that they are more like *solitarius* than *cassini* is quite small. Nearly all the intermediate specimens are really identifiable with *cassini;* in fact, of twenty-nine specimens in the collection which have been labeled indifferently *cassini* and *solitarius*, I find that twenty are referable to *cassini*, and cannot by any means be identified with *solitarius*. Of the remaining nine, three are so nearly intermediate that they might with about equal propriety be assigned to either, leaving six with a decided leaning toward *solitarius*. It needs, however, but an instant's comparison of these with the ordinary Eastern *solitarius* to show that although closely resembling that species, it would be going too far to say that they are typically the same. In connection with the rest of the series they are clearly intermediate, but on the *solitarius* side of the line.

The testimony of the series as a whole seems to show pretty conclusively that the solitary vireo proper does not occur in the West, and that all specimens which have been so identified are either *cassini* or are intermediate between the two; the latter class, in fact, furnishing the evidence that the two inter-grade, and hence that *cassini* is a variety of *solitarius*.

The only alternative would be to throw *cassini* out entirely and refer all Western specimens to *solitarius*. But, in our judgment, typical specimens of *cassini* are now too numerous and show too decided and constant differences to warrant such a procedure.

The habitat of Cassin's vireo may receive a moment's attention. Its summer home appears to be strictly limited to either slope of the Sierra Nevadas, from Washington Territory to Southern California. I can find no specimens (including under the head of *cassini* all individuals hitherto supposed to be *solitarius*) from the Rocky Mountains in *spring or summer*.*

As a migrant in fall the occurrence of the Cassin's vireo in the latter range is not surprising, or no more so than that of several other Sierra Nevadan birds, as *Junco hyemalis*, *Turdus pallasi nanus*, *Dendroica townsendi*, and *occidentalis*, &c.

I have alluded in a foot-note below to a specimen, the coloration of which is intermediate between *solitarius* and *plumbeus*. Such specimens do not appear to be as common as in the instance of the Cassin's vireo, but I have seen too many such to render the relationship of the two former birds at all doubtful in my own mind. With its notable increase of stature, and the laying off of nearly all the bright tints that distinguish *solitarius*, *plumbeus* might well pass for a different species, but for the fact that specimens of unquestionable intermediate character have been repeatedly taken; so that consistency would seem to demand that its near relationship to *solitarius* should be formally as well as tacitly admitted. Although this race possesses an average size considerably in excess of *solitarius*, the latter occasionally leads well up to its smaller individuals. *Turdus pallasi*, with its race *auduboni*, furnishes precisely the same phenomenon of increase of size coincident with a mountain habitat.

Of the two Western varieties of the solitary vireo, *plumbeus* appears to be the best marked. This is not because typical examples of it are any more readily recognizable than of *cassini*, but because intermediate specimens of the former appear to be less common; in other words, *plumbeus* appears to be further advanced in the process of differentiation, and hence to be more constant to its type. Too much stress should not, however, be laid upon this apparent fact, since the locality of specimens of this race appears to be an important factor. Thus, all specimens of the plumbeus vireo that we have seen from the neighborhood of Fort Whipple, Arizona, the region whence described by Dr. Coues, are extremely typical; but from points farther north, as Forts Laramie, Bridger, and thereabouts, nearly all—perhaps all—are to a varying extent intermediate.

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* A specimen, No. 11,064 of Nat. Mus. Res., taken at Fort Bridger in May by Drexler, was labeled *solitarius* and so referred to by authors. This I ascertain upon examination to be the plumbeous vireo (*V. solitarius plumbeus*). Its colors are those of *plumbeus*, with the addition of a slight admixture of green, it being in fact intermediate between that form and *solitarius*.

Similarly, the eastern slopes of the Sierras and Cascades appear to furnish, in summer at least, nothing but typical *cassini*, while from the Calaveras Grove California, and other localities on the western side of the mountains, we have both typical and intermediate specimens, both styles breeding. As bearing on the subject, I may recall the fact that many of the shrikes from the same localities are scarcely distinguishable from specimens from Florida (*ludovicianus*).

To sum up, the solitary vireo, like many other birds, appears to be divisible in three distinct races, according as it inhabits the eastern, the middle, or the Pacific provinces. Each has its own restricted summer habitat, where it alone is found. In fall the two Western mingle, to some extent, during the general dispersion attendant upon the fall migration.

The following figures indicate the size of each of the three forms:

*Solitarius.*—Average of 11 specimens: Wing, 2.92; tail, 2.23; bill, .40; tarsus, .71: largest individual, 3.06, 2.35, .38, .72; smallest individual, 2.80, 2.15, .40, .73.

*var. plumbeus.*—Average of 17 specimens: Wing, 3.14; tail, 2.40; bill, .43; tarsus, .74: largest individual, 3.22, 2.45, .43, .77; smallest individual, 3.03, 2.25, .43, .74.

*var. Cassini.*—Average of 28 specimens: Wing, 2.82; tail, 2.23; bill, .41; tarsus, .73: largest individual, 2.93, 2.27, .42, .67; smallest individual, 2.70, 2.01, .43, .73.

## LANIIDÆ—Shrikes.

### LANIUS Linnæus.

*L. ludovicianus excubitorides* (Sw.). White-rump Shrike.

Most numerous in summer, when it lives chiefly in the lower foot-hills among the sage-brush. Some appear to remain all winter in the latitude of Carson.

The northern shrike (*C. borealis*) also appears here in fall.

## TANAGRIDÆ—Tanagers.

### PYRANGA Vieillot.

*P. ludoviciana* (Wils.). Louisiana Tanager.

A summer visitor of the mountains, as high up at least as the Columbia River.

A nest found June 26, near Susanville, Cal., contained three young and two eggs, the latter just on the verge of hatching. The nest was a loose structure of rootlets, similar to the usual style of the *P. rubra*, and was placed on the extremity of a limb of a cottonwood, about fifteen feet from the ground.

As a rule, our tanagers lay but three eggs, and five must, I think, be a rather unusual complement.

## FRINGILLIDÆ—Sparrows, Finches.

### LOXIA Brisson.

*L. curvirostra americana*, Wils.

This crossbill becomes numerous in the mountains and on the foot-hills in fall. It is presumably a resident in Oregon, although I cannot find any direct evidence to this effect.

### CARPODACUS Kaup.

*C. purpureus californicus* (Bd.) Californian Purple Finch.

A single individual of this species was taken at The Dalles on the Columbia in October from a flock of pine finches. This is the first record of its occurrence at any point along the eastern slope, its distribution being to the west of the mountains from as far north as the Straits of De Fuca (Cooper) to below San Francisco.

*C. cassini* Bd. Cassin's Purple Finch.

An abundant summer inhabitant in the neighborhood of Carson, and, although, perhaps becoming rather less numerous as northern California is reached, the species persists to the Columbia River. This, I believe, gives it a more northern extension than has hitherto been supposed. In summer they are quite local, and crowd into a certain neighborhood of a section to the total disregard of others which, perhaps, appear no less suited to their economy. I found communities of considerable size thus colonized in certain parts of the pine woods about Eagle Lake, California, and elsewhere. In common with others of their kin they are delightful singers, and the burst of melody which greets the ear of the chance passer by as he happens upon one of these musical oases in the generally silent forests is no less pleasing than it is unexpected. Like the common goldfinch (*C. tristis*) the males have the habit of singing in chorus, and it takes very little imagination to construe their efforts into rival contests. Whether they possess such significance to the birds themselves or not, it is certain that each individual appears to sing his loudest and best, as though trying to drown the notes of his neighbor, or, perhaps, too well pleased with his own efforts to care for aught else. The effect, as the medley of delightful strains goes ringing through the leafy arches of the pineries, is pleasing in the extreme.

The nests, of which I have seen many, were all placed on large pines and well out toward the ends of the lower limbs.

By the latter part of June nearly all the pairs were feeding young, and none of the nests that were accessible contained eggs.

*C. frontalis* (Say). House Finch.

An abundant species wherever found. It was not observed much farther north than Honey Lake, Northern California.

### CHRYSOMITRIS Boie.

*C. tristis* (L.). Common Goldfinch.

A common summer resident at many points. Found on the Columbia River in October.

*C. pinus* (Wils.). Pine Finch.

This species occurs along the whole eastern slope in fall and winter, and passes the summer in the coniferous belt in much of its extent. In Oregon, from August on, wherever I penetrated the mountains, I was almost sure to run across flocks of these finches, whose twittering notes often betrayed their presence in the tops of the tall pines and spruces when the birds themselves were only visible upon patient scrutiny.

### PASSERCULUS Bonaparte.

*P. savanna alaudinus* Bp. Western Savanna Sparrow.

Numerous in all wet meadowy lands, and as much so in Oregon as farther south.

A nest taken near Washoe Lake, Nev., May 22, contained four fresh eggs. These are rather peculiar both in shape and in markings, although the differences probably represent nothing but individual variation and are not distinctive of this western race. They are of a greenish-white ground color, heavily blotched in a more or less confluent ring at the larger ends with burnt sienna and various shades of lavender. They are short and rounded in shape, measuring $(68\times55)^2$, 66×54, 65×53.

*P. savanna sandvicensis* (Gm.). Sandvich Sparrow.

The preceding form is the type that prevails in summer all along the eastern slope. In fact at only one locality did I detect the presence of the present bird, viz, on Crooked River, Oregon, in September.

A sandy pasture at this point proved favorite ground for the savanna sparrows, and a walk through the weed patches usually resulted in starting up scores. Among the rabble I noticed one day an individual of apparently larger size than the rest, and upon shooting discovered it to be of the present race. Further search resulted in the acquisition of one additional specimen. So far as known *sandvicensis* is a strictly coast form; but its presence here is, after all, by no means remarkable, since in the fall migration a few might readily find their way up the Columbia River and so move south along the eastern slope. As I did not find it elsewhere, I judge it to be rare.

### POOECETES Baird.

*P. gramineus confinis* Bd. Western Grass Finch.

Numerous in the valleys. Noted no farther north than Southern Oregon, but without doubt, extending into Washington Territory.

## CHONDESTES Swainson.

*C. grammaca* (Say). Lark Sparrow.

This species was lost sight of about one hundred miles north of Carson. It doubtless occurs in the low valleys, quite up into Oregon; in fact, Suckley records a single specimen from The Dalles, on the Columbia.

## ZONOTRICHIA Swainson.

*Z. albicollis* (Gm.). White-throated Sparrow.

Dakota has hitherto been given as forming the western limit of this sparrow. Nevertheless, it seems probable that it is to be added to the list of eastern species that reach the Pacific on the northwest coast and summer at the point where the Rocky Mountains dwindle away and admit of free passage. At all events, the presence of the white-throated sparrow was detected on the Columbia River, about forty miles from The Dalles, and thus beyond the eastern slope, and one of the two individuals seen was captured. I presume that it is by no means scarce here, although as the individuals noticed were seen only an hour or so before camp was broken for the return up the river, no opportunity was had for a satisfactory investigation of the matter.

*Z. leucophrys* (Forst.). White-crowned Sparrow.

As almost everywhere throughout the West, this sparrow occurs along the eastern slope in great numbers during the migrations. It is also numerous in these mountains in summer, resorting to breed to the willow thickets and aspen groves along the streams.

A nest found in Eastern California, June 20, contained four eggs but slightly advanced. Several found on the 24th held young. The nests were quite typical of the ground-building sparrows, being outwardly composed of weed-stalks with an interior lining of fine grasses and horse hairs, the whole snugly hidden away with a sparrow's cunning beneath a small bush.

The eggs are of a faint bluish green, irregularly and profusely spotted with reddish brown, which is most conspicuous at the larger ends.

*Z. gambeli intermedia* Ridgw. Ridgway's Sparrow.

Flocks composed of this and the previous bird frequently fall into the path of the collector in this region during spring and fall. The present bird was not found in the mountains as a summer resident, and I believe it goes farther north to breed. Mr. Ridgway, indeed, in his recent report to King,* mentions this bird as nesting in numbers at Donner Lake Pass in the Sierras; but, as I now learn, he believes that his identification was incorrect (circumstances not permitting specimens to be obtained), and that the species thus referred to was, beyond doubt, the *Z. leucophrys*. This agrees fully with my own experience in this region, and leaves us with no record of the breeding of the *var. intermedia* in the Sierras.

I have elsewhere presented facts bearing upon certain differences in the migrations of these two *Zonotrichias*, and have referred to the very extensive overlapping, eastward and westward, of their respective habits, urging that these considerations, coupled with the constant, albeit slight, differences in coloration between the two, were sufficient to warrant the conclusion that *intermedia* was not a race of *leucophrys*. I am more than ever convinced of the truth of this. The *Z. leucophrys* is now known to breed on the northern frontier from the Atlantic to the Rocky mountains, and thence to the summit of the Sierras, and to follow the trend of these ranges far to the southward. Over all this immense region it maintains its characters with perfect consistency, there appearing in fact to be no appreciable differences between specimens taken on the Atlantic and others from its most remote western point. So far, then, as geographical considerations offer any evidence, it is manifestly absurd to consider *intermedia* as the "western" representative of a bird that in its typical condition is found in nearly every portion of the West, and that, too, breeding.

On the other hand, that the relations of *gambeli* and *intermedia* are those of species and variety seems perfectly certain, and the two may be so treated in perfect conformity with well ascertained laws of geographic variation, *gambeli* being the darker coast representative of the pale, more northern (?) interior form *intermedia*.

*Z. coronata* (Pall.). Golden-crowned Sparrow.

This sparrow occurs along the eastern slope during the fall migration, but by no means in such immense numbers as distinguish its presence to the westward. On the contrary, its numbers are limited to the comparatively few that find their way into the bands of white-crowned and Ridgway's sparrows, and with them perform the journey southward, or winter in favorable localities. Suckley, however, speaks of the Golden-crowned Sparrow as an abundant summer resident about The Dalles.

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*Ornithology of United States Geological Exploration of the Fortieth Parallel, Clarence King, in charge, p. 471.

### JUNCO Wagler.

*J. oregonus* (Towns.). Oregon Snowbird.

This snowbird appears to pass the summer among the mountains, from about the latitude of Carson, Nev., northward, and is the only one of the genus that inhabits the Pacific province.

A nest found June 23 contained young. It was placed on a hillside in a little patch of an evergreen shrub that raised above the earth sufficiently to screen the nest, the top of which was sunk on a level with the ground. This may have been an unusually late brood, for I had taken fully fledged young some few days earlier.

A second nest, found August 2, held three young, several days old.

I subjoin a description of the young in the first or nest plumage, remarking that in this condition the young of all our snowbirds resemble each other very closely, those of several of the forms, in fact, being distinguishable only with great difficulty.

First plumage: Prevailing tint above rufous, the feathers streaked medially with black; wings and tail blackish-brown, each feather edged with rufous. Throat, breast, and sides profusely spotted with black; belly of a fulvous white; sides washed with rufous; first outer tail-feather always, usually the second, sometimes the third, white

### AMPHISPIZA Coues.

*A. belli nevadensis* (Ridgw.). Artemisia Sparrow.

This sparrow breeds abundantly among the artemisia wherever it grows, and even follows it to a considerable altitude in the mountains, although the sage plains, at their lower levels, appear to be the proper home of the bird. The species occurs less abundantly in Northern California than to the southward.

In the vicinity of Carson, where I found several nests, its eggs are laid about May 15. As nesting sites sage bushes were invariably selected. Dried weed-stalks make up the bulk of the structure, with an interior of the soft, fibrous sage bark, inside which is the lining proper, of sheep's wool, which is readily obtained by the birds almost anywhere in this country.

The eggs vary much in the exact character of their markings, as also, to some extent, in size. With a faint greenish-white background, they are spotted, much less heavily at the smaller than at the larger end, where the markings are often accumulated into a circle, with various shades of brown inclining toward sienna, with lavender, and faint purple. The sienna is often laid on in the shape of scratches or blotches, so densely as to appear almost black. Altogether the appearance of the eggs of this species is peculiar.

Two sets measure as follows: $(79\times58)^2$ $83\times58$ $75\times58$; $(76\times58)^2$ $77\times57$ $78\times57$.

### SPIZELLA Bonaparte.

*S. monticola* (Gm.). Tree Sparrow.

A flock of tree sparrows was seen upon the Columbia in October, but, owing to a failure to interest my mule in the matter, no specimens were actually secured.

Dr. Cooper leaves a note to the effect that he saw what he took to be tree sparrows in the Sierras, and Suckley obtained a bird at The Dalles in winter which he identified, per book, as of this species. So the tree sparrow may be presumed to be a fall migrant and winter resident of this region on both slopes of the Sierras; but it is probably less common than farther east.

*S. socialis arizonæ* Coues. Western Chipping Sparrow.

A common summer inhabitant of the eastern slope. It is found in Washington Territory, west of the mountains, and doubtless to the east, although it was not met with about the Columbia, perhaps owing to the lateness of the season.

*S. breweri*, Cass. Brewer's Sparrows.

This quaint little sparrow is almost as characteristic an inhabitant of the sage-brush plains as the Bell's finch. Together with the latter bird and an occasional sage thrush this species makes up the usual avian life of these forbidding wastes and, in numbers at least, the Brewer's sparrow is the most conspicuous of the three. Living often far distant from water, and with no hint of the usual attractive surroundings that we come to consider as being necessary to the happiness if not the very existence of bird life, our little sparrow appears to be perfectly contented with its lot and unmistakably expresses himself so in the unobtrusive but pleasant little songs he sends forth at odd times during the entire day.

In what appears to be somewhat exceptional instances, this sparrow varies its habitat to a considerable extent. Thus I have occasionally found the summits of the high peaks to be occupied, together with a few other species, by the Brewer's sparrow. The low brush or "scrub" into which the luxuriant sub-alpine vegetation dwindles, as the higher altitudes on the mountains are reached, seem to offer conditions sufficiently similar to its more usual haunts to meet all requisites. In such spots the Brewer's sparrows were often very numerous, while the presence of young birds sufficiently attested the fact that here was their summer abode.

The nests of this sparrow are very much like the usual structures of the "chippy," but appear to be invariably placed in a low bush. Much variation appears in the shape as well as the markings of the eggs. The latter usually occur as blackish spots and blotches; these are generally few in number, and are mostly at the larger end, leaving the greenish-blue ground unoccupied for its greater part. Some specimens show no traces of black, but the spotting assumes a reddish-brown or neutral tint, often confluent in a ring at the larger end. Other sets have only a faint irregular freckling of the same. The smaller eggs exhibit a more or less decided pyriform shape, while those of larger size vary in the direction of a more elongated oval. The following measurements express these variations in size: $(67\times48)^2$, 68×47; $(63\times48)^2$, $(62\times47)^2$; 69×50, 68×52, 65×50, 69×53.

### MELOSPIZA Baird.

A study of the song sparrows of the United States and adjoining regions reveals an extraordinary amount of variation, coinciding more or less closely with definable geographical areas. Others of our species are possessed of a similar wide range, but in no other are exhibited such marked variations of color and such mutations in size as in this.

The song sparrow, although apparently nowhere a permanent resident, in the strict meaning of that term, that is, to the extent of the same individuals remaining in the same place throughout the year, is yet migratory to only a limited degree; and it is probable that the change of locality with the migrations is, in the instance of none of the forms, very marked. It is doubtless to this localization and the resulting constantly-exerted influence of the same circumstances of environment, that we are to attribute the extraordinary tendency in this bird to develop into races and offshoots, according as its range brings it under differing conditions. As Dr. Coues happily phrases it, "Migration holds species true; localization lets them slip." And nowhere is to be found a better illustration of this aphorism than is presented by the song sparrow.

A recent examination of the extremely large collection of song sparrows in the Smithsonian Institution, in connection with the extensive suite gathered by the Expedition, has developed some facts that appear to be of sufficient value and interest to warrant brief mention. Here as elsewhere the variation, through which the forms are indicated, are of two kinds, viz, a variation in size and a variation in coloration; nor is it easy to say in which direction the changes are most pronounced.

The only song sparrow found in eastern United States, and which extends from the coast as far west as Nebraska and Indian Territory, is the *M. melodia*; and of all the forms, except possibly *insignis*, this appears to be the most constant in the maintenance of its peculiarities over its wide habitat. In fact, so far as color goes, the variation appears to be scarcely noticeable; nor is the variation in size very marked. Such as it is, it appears to bear out the general rule of an average increase of size to the northward. This law, it may be remarked here, appears to be equally applicable also to all the other races. The general sameness in the topographical character of the eastern region and the resulting similarity of climate is doubtless the chief cause of the slight departure from type to be observed in *melodia* throughout its range.

The Rocky Mountains as far to the north as Oregon and to the south to our southern border, and the entire region west to the Sierra Nevadas, is occupied by the var. *fallax*. This bird is distinguishable from *melodia* by a generally paler tone of coloration, by a decided increase in size, especially of wing and tail, and by a slightly longer and considerably more slender bill. The intergradation of this form with *melodia* is readily traceable and complete. From the very varied nature of the country occupied by *fallax*, it being broken up by lofty mountain ranges, and the ensuing differences of climate, considerable discrepancies might naturally be expected in specimens of this race from different localities. Such proves to be the case; and, in examining a large series, the attention is often arrested by some slight phase of color which is often so intangible as to practically elude definition, but which occasionally is sufficient to identify all the individuals from some one limited neighborhood. So frequently is this impression received, that it would almost appear as if each locality in the middle region furnished a type of its own, exhibiting the main characters of *fallax*, but differing more or less appreciably. Thus the region of the Gila River affords a style of this race quite distinct from any other. The principal variation is seen in the very pale reddish tint, with scarcely a trace of dusky, which is especially noticeable in the streakings on the breast.

Another phase from Camp Harney, Oregon, is remarkable for its pale grayish tints. Such inter-races are doubtless the result of causes very local in their action, and are so slight and inconstant as to deserve nothing more than passing notice.

Reaching the foot-hills of the Sierras we find *fallax* beginning to assume new characters, and in the mountains and along the western foot-hills it finally merges into var. *heermanni*. This form is characterized by a much darker shade of brown than either *fallax* or *melodia*, and by a bill much stouter than the former, but less robust than the latter. *Heermanni* has usually been considered the Californian song sparrow, the term thus including indifferently the birds both from the coast and the interior. But this is a mistake. The type now before me came from Fort Tejon, and it is in the interior only that the style to which this name was applied is met with.

Reaching the coast, another form is for the first time encountered. This is the var. *samuelis*, of which the *gouldii* of Baird, as correctly determined by Mr. Ridgway, is the fall plumage. Hitherto some three or four individuals from the vicinity of San Francisco have been taken as representing all that was known of this race. But no fewer than forty-six specimens are now at hand that agree well with the type, and are unquestionably referable here. In point of fact, it is *samuelis* alone that occurs in summer along and near the Californian coast, and nearly all published accounts of the habits, nesting, &c., of the song sparrow of California are to be taken as referring to it. This form rests chiefly upon its small size, it being by considerable the smallest of all the races, and the very dark, almost black, color of its prominent streakings. But it is upon a basis of size alone that it can be separated from *heermanni*, both agreeing in essential points of coloration. In fact, the question might well be raised whether it is necessary to recognize by distinct names two forms from this region. I have on the whole deemed it expedient to do so, as the difference of size, especially of bill, in specimens from the respective habitats of the two, as indicated, is pronounced and quite constant, readily sufficing in the great majority of cases for their identification. Thus in over thirty specimens of *heermanni* from Stockton, Cal., kindly furnished by Mr. Belding, I find no marked differences, and all the individuals from the interior that have been examined, representing many localities, agree in large size, the average being considerably in excess of those from the coast. A series of nine males, collected about Oakland, for the opportunity of examining which I am indebted to the courtesy of Mr. D. S. Bryant, of San Francisco, are similarly constant to the coast type so far as size is concerned, but vary somewhat in coloration. The differences are chiefly as to the number and size of the black streakings below, two of the nine being the darkest, and, on the whole, the most typical examples of *samuelis* I have seen.

Of the var. *mexicana* Ridgway, from Southern Mexico, little can be said, since the name rests upon a single specimen. This individual appears to be recognizable from the other races by its rather peculiar coloration, the streakings being very broad as well as black, and by its small size. More specimens are necessary to determine its true relations.

Var. *guttata* next invites attention. This is characterized by a darker, more rufescent type of color; the streaks on the dorsum are very indistinct, in some almost wanting. The bill is proportionately more slender than in any of the preceding forms.

The typical home of this variety is the Columbia River region, coastwise. But long before reaching that point evidence is afforded by specimens of intermediate character of the change to appear farther to the north. Thus fall and winter specimens from Nicasio, evidently reared farther north, are unquestionably intermediate in coloration between *samuelis* and *guttata*, while during the past season specimens were obtained by the expedition in Oregon upon the eastern slope, thus approximating the habitat of *fallax*, that are no less intermediate between that central region form and *guttata*, the two forms to the northward evidently passing, by insensible stages, into the latter.

Var. *rufina* is simply *guttata* with the tendencies of the latter carried a step or two farther, with increase of latitude. The rufous of *guttata* in extreme cases becomes a reddish sepia brown; the size is somewhat larger, the bill rather more slender. This is *rufina* as found about Sitka and southward.

Upon certain of the Alaskan Islands occurs *insignis*. This gigantic sparrow is distinguished, in addition to its great size, by a much paler, grayer phase of color than its nearest geographical neighbor, *rufina*. The streaks, instead of being nearly or quite obsolete, as in that form, are well defined and of an umber brown.

Of *insignis*, Baird and Ridgway say: "Between *M. melodia* of the Atlantic States and *M. insignis* of Kodiak the difference seems wide, but the connecting links in the inter-regions bridge this over so completely that with a series of hundreds of specimens before us, we abandon the attempt at specific separation." * * * It cannot be denied that the var. *rufina* from Sitka is nearer *insignis*, by many degrees, than the *melodia* of the East, and, as has just been indicated, nothing is wanting in the chain of evidence to establish the connection between *rufina* and *melodia*. But, while admitting the possibility that the relations between *insignis* and *rufina* may be as close as that of races, we feel justified in asserting that the inter-gradation, necessary to establish this, cannot be shown from the material accumulated up to the present time. Measurements appended below demonstrate that between the largest specimen of *rufina* in the collection and the smallest of *insignis* there is a very wide gap. Nor does there appear to be any known law of geographical variation to account for this.

As has been stated, and in conformity with a well-known law, increase of latitude seems to be accompanied by a general increase of size. But this fails of application in the case of *insignis*, since Sitka, the typical locality of *rufina*, is in the same latitude with Kodiak; while one specimen of *rufina*, by no means the largest, is present from Litnya Bay, which is slightly farther north than that island.

Possibly its insular habitat may be deemed sufficient to account for the marked characters of *insignis*, since in their power of impressing peculiar features upon their zoological inhabitants, islands seem to have a law of their own.

Color alone considered, although in this respect *insignis* is well marked, the step from *rufina* appears inconsiderable when it is remembered the great change that has been traced between *rufina* and *melodia*. The gap in size is much more important. Analogy in cases like the present has proved far from being always a safe guide, and since, by the test of inter-gradation, the only reliable one, *insignis* remains widely apart from the others, I deem it far safer to allow *insignis* to stand upon its merits until its claim to distinct specific rank be actually disproven.

Measurements are appended to show the average size of the various races; the largest and smallest individuals of each series are also given.

| | Wing. | Tail. | Bill. | Tarsus. | Depth of culmen. |
|---|---|---|---|---|---|
| *M. melodia* (average of 21 specimens) | 2.60 | 2.80 | .46 | .83 | .30 |
| Largest | 2.77 | 2.90 | .47 | .78 | .29 |
| Smallest | 2.32 | 2.60 | .45 | .78 | .30 |
| *var. fallax* (average of 23 specimens) | 2.69 | 2.94 | .44 | .84 | .25 |
| Largest | 2.92 | 3.17 | .43 | .83 | .27 |
| Smallest | 2.35 | 2.52 | .43 | .77 | .25 |
| *var. heermanni* (average of 13 specimens) | 2.61 | 2.82 | .45 | .84 | .28 |
| Largest | 2.80 | 2.93 | .46 | .84 | .28 |
| Smallest | 2.45 | 2.70 | .45 | .83 | .24 |
| *var. samuelis* (average of 46 specimens) | 2.41 | 2.48 | .45 | .84 | .26 |
| Largest | 2.60 | 2.64 | .45 | .86 | .26 |
| Smallest | 2.13 | 2.23 | .40 | .76 | .23 |
| *var. mexicana* (one specimen) | 2.52 | 2.83 | .46 | .87 | .26 |
| *var. guttata* (average of 23 specimens) | 2.63 | 2.89 | .44 | .90 | .26 |
| Largest | 2.78 | 3.14 | .46 | .93 | .......... |
| Smallest | 2.42 | 2.59 | .45 | .83 | .......... |
| *var. rufina* (average of 7 specimens) | 2.78 | 2.87 | .48 | .92 | .26 |
| Largest | 2.96 | 3.12 | .52 | .93 | .29 |
| Smallest | 2.61 | 2.64 | .43 | .87 | .25 |
| *M. insignis* (average of 20 specimens) | 3.26 | 3.39 | .61 | 1.07 | .30 |
| Largest | 3.40 | 3.40 | .50 | 1.13 | .32 |
| Smallest | 3.13 | 3.35 | .57 | 1.07 | .29 |

*M. melodia fallax* (Baird). Rocky Mountain Sparrow.

This form was met with at several localities at the foot of the eastern slope, although it is along here that the change towards the *heermanni* type is first indicated; some specimens, indeed, from near Carson, Nev., appear to be referable to the latter variety.

*M. melodia guttata* (Nutt.). Oregon Song Sparrow.

If the song sparrows taken in Oregon at the base of the mountains in September are summer residents, as is doubtless the case, then the habitat of this race includes a restricted portion of the eastern slope. The specimens alluded to, from Warm Springs Agency and Crooked River, while not typical, are nearest to the above race. At The Dalles, on the Columbia, in October, these birds were extremely abundant in the hedgerows and brier-patches and along the small streams. At this locality the specimens were nearly typical *guttata*.

### PASSERELLA Swainson.

*P. iliaca megaryncha* (Bd.). Thick-billed Sparrow.

This curious sparrow is present along much of the eastern slope in summer, and probably reaches quite to the Columbia River. It was first seen near Carson, Nev., May 16, being at this date found in considerable numbers in the wild-cherry brush along the cañon sides. It was apparently still on its way north, although Mr. Ridgway states that the bird begins to move north about the 1st of March. At a later date I found the birds quite common in the scrub on the top of Thompson's Peak, at an elevation of rather over 7,000 feet; and by the last of July fully fledged young were taken. The bird is eminently a mountain form, thick brush being the prime essential to its choice of a home. It never, I think, descends into the low valleys, which, on the other hand, seems to be preferred by the allied form *schistacea*.

### HEDYMELES Baird.

*H. melanocephalus* (Sw.). Black-headed Grosbeak.

By May 15 this species was very numerous about Carson, and appeared to be mating. Their food at this season appears to consist largely of the soft buds of various shrubs, especially of the willows.

How far north the species goes I am not aware, my note-book simply furnishing the statement of its presence in Northern California, but in much diminished numbers. As it reaches Fort Steilacoom along the coast, it may attain a similar latitude in the interior. Its habits of nidification appear to be everywhere about the same, and to correspond pretty closely with those of the rose-breasted. Its architecture is of the simplest kind, the nest being made up of fine weed-stalks and similar light material, which are arranged in as circular a form as the stiff, unyielding nature of the stems will allow. A lining of fine rootlets disposed in a shallow circular form completes the structure. This is almost always placed toward the extremities of the lower limbs of trees, often overhanging a stream or deep ravine; more rarely the nest is placed on bushes.

Three eggs are occasionally laid, more usually two. They are light blue, irregularly spotted with reddish brown and purple; usually, though not always, most thickly at the larger ends.

Considerable variation in size obtains between sets. Two measure 1.05 × .73, 1.02 × .75, and .95 × .67, .93 × .68.

### CYANOSPIZA Baird.

*C. amœna* (Say). Lazuli Finch.

A common summer resident about Carson, but met with less frequently toward the north. Nevertheless, Cooper reports it from Puget Sound, and Suckley found it in numbers in spring at The Dalles, Oregon. It was found by us to breed up to an altitude of 7,000 feet.

### PIPILO Vieillot.

*P. maculatus megalonyx* Bd. Long-spurred Towhee.

This, the only form of the towhee met with by us, is extremely numerous along the eastern slope as high as the Columbia River. I fully agree with Mr. Ridgway that specimens of the *Pipilo* found along the eastern slope of the Sierras are absolutely indistinguishable by external characters from *megalonyx*. They appear to show no approach to *oregonus*, as that variety is illustrated by individuals from the northwestern coast. Nor have I been able to find in the habits, songs, and notes of the *Pipilo* of the Sierras the striking peculiarities which had such weight with Mr. Ridgway as to induce him to identify it as *oregonus*, in the face of its apparent likeness to *megalonyx* in form and colors. On the contrary, the habits of the towhees, as they have fallen under my notice in the Rocky Mountains and in the Sierras, have appeared to be essentially the same. Mr. Ridgway was especially impressed with the fact that the mewing call, which all observers have attributed to *megalonyx*, was never heard by him from the form found near Carson. But a line in my note-book records the fact that this same mewing note was the *only* one heard by me at this locality. Cooper, however, says that the call-notes of these two forms are alike, so that they have no distinctive value.

In the matter of birds' habits, differing circumstances of observation enter so largely as factors in the results obtained by different observers, that such evidence becomes, at best, but a precarious means of discrimination, especially between birds closely related; as, for instance, the members of the genus *Pipilo*. Apparent discrepancies in records are by no means always, perhaps, in fact, only in comparatively rare instances, attributable to inaccuracies of observation. But too often the fact is overlooked, or practically ignored, that in birds of the same species, at the same locality, and even at the same time, there may be a very marked diversity of habits, which is an expression of nothing more or less than individual taste or the result of quite adventitious circumstances. Such being the case, it is scarcely to be wondered at that in distant localities, where the observer is ever on the alert for new facts, he should, not infrequently, be misled into false comparisons by a note new to his experience, or some hitherto unnoticed habit, which, perhaps, had it been marked nearer home, would have attracted but casual attention.

By the above, however, it is by no means intended to imply that such matters are not entitled to a place as aids to the proper understanding of the relation of species to each other. It is doubtless true that there is occasionally to be noticed certain changes in respect to the habits and songs of birds that accompany changes of locality, and which may furnish the first clew to external variation, in support of which they may be adduced as additional and valid testimony. But it is no less true that the purely individual variation in birds' songs and habits is often very great; in truth, such appears to be the rule rather than the exception; a fact which should be kept fully in mind when such features are made to enter into the question of specific or varietal distinctions.

*P. chlorurus* (Towns.) Green-tailed Finch.

This sparrow is rather numerous in summer along the eastern slope, and reaches well into Oregon, if not, indeed, to the Columbia River.

Several nests with eggs were found in July.

## ALAUDIDÆ—Larks.

### EREMOPHILA Boie.

*E. alpestris chrysolœma* (?) (Wagl.). Horned Lark.

The usual central region form of the horned lark occurs rather numerously about Carson in summer upon barren pasture lands, sage brush, and alkaline flats, &c. Its breeding range extends into Southern Oregon, and perhaps even farther northward.

It appears to me that the identity of this central region form with the chrysolæma of Mexico is open to doubt and that its true place may be elsewhere. Pending an examination of the question, however, I employ the name in current use.

## ICTERIDÆ—Orioles.

### XANTHOCEPHALUS Bonaparte.

*X. icterocephalus* (Bp.). Yellow-headed Blackbird.

This blackbird is extremely abundant in all suitable localities along the eastern slope far towards the Columbia River. In the latitude of Carson, it begins to breed somewhat before the middle of May, and by the 15th the tule beds, to which it always resorts, will be found to contain nests in all phases of construction, while a few pairs, more ardent or enterprising than the rest, possess their full complement of four eggs. By the 1st of June nearly every nest contained eggs in various stages of advancement, while in not a few instances the young had already made their appearance.

The habit of colonization at this period is carried in this species to an extreme not observable in any other of the family, unless, perhaps, it be the tri-colored, as that bird is found in Southern California. Thousands flock together to form a happy, noisy community, their songs filling the swampy recesses with a confused and indescribable medley. Though by no means melody of a high order, they fall not unpleasantly upon the ear rightly attuned to bird music, when they are correctly interpreted as a mere rendering into audible sound of the overflowing jollity and good humor of the birds as they trill forth the notes in a happy-go-lucky sort of style from the swaying reeds.

The nests, while usually built well up on the reeds and fastened to the upper stalks, are not always so situated, but are occasionally, as was noticed in several instances at Washoe Lake, placed close to the marshy ground among the coarse grasses. When such is the case, the structure is very similar to that of the common red-wing under like circumstances. As the nests so placed were among the earliest found, it is probable that the more usual positions—high up on the reeds—is exchanged for one affording better protection and security for the early broods.

Dr. Coues tells us that the males appear to desert the females during the period of incubation. But if this be a matter of observation, I think it is, to say the least, unusual. I have found the males of this species as domestic in their habits and as assiduous in attention to their young as any of the family. It is true, as observed by Mr. Nelson, that they are much shyer than their mates, the natural result of their more conspicuous colors and their distrust of danger on account of this. They are hence less often seen about the nest when it is disturbed.

### AGELÆUS Vieillot.

*A. phœniceus* (L.). Red-winged Blackbird.

An abundant summer resident along the eastern slope. More or less winter about Carson.

*A. phæniceus gubernator* (Wagl.). Red and Black-shouldered Blackbird.

This form is less abundant than the former as well as less generally distributed along the eastern slope. It appears, as a rule, not to be found much east of this line, but it is reported from Camp Harney, Oregon, by Captain Bendire. It is noticeable in this connection that none of the specimens which are referable to this form from localities east of the mountains represent it in its typical condition. Thus from the neighborhood of Reno, Nev., at the eastern base of the Sierras, close to the border of California, we have a series of specimens the males of which have the crimson shoulder-patch bordered narrowly with light buff, *each feather of which border is black-tipped.* Such individuals appear to be just about half-way in development towards *gubernator*. It is interesting to note that in this same locality the *A. phæniceus* is also present (both breeding), and in as truly typical dress as anywhere in the West. What proportion of individuals represent either form I cannot say, but believe that by far the largest percentage of the *agelæi* here are *phæniceus*.

It would thus appear as though the eastern blackbird extends to about the line of the mountains unchanged; that here, the influences, as of climate, &c., first begin to be felt, which, only partially operative here, as they become intensified farther to the west result in effecting the color change which is seen in typical *gubernator*. In this instance it would appear that the influences are sufficiently strong to affect only a proportion of individuals, which from obscure reasons are more susceptible to their workings; while the majority remain true to their type.

If, as is usually understood to be the case, color varieties are identifiable with certain limited areas of distribution, it follows that, as in the present instance, where the species inhabits continuously a wide region, the changes of environment are more or less gradual, and hence at certain points or along a certain line of distribution it is brought under conditions which are intermediate in character and force—a sort of neutral ground, as it were. From such regions come the specimens which, though often the cause of no little perplexity to the naturalist from the difficulties in the way of their proper identification, are yet full of interest as furnishing indubitable proof of the intergradation of forms.

### STURNELLA Vieillot.

*S. magna neglecta* Aud. Western Meadow Lark.

Very numerous throughout this whole region.

Most of the nests discovered were arched over, thus conforming to the usual plan of structure. In one instance the birds seemed to find the protection of the tall grass an ample safeguard, and the nest was merely a flat open structure, with no attempt at a roof.

### ICTERUS Brisson.

*I. bullocki* (Swains.). Bullock's Oriole.

Very numerous about Carson and to the northward along the base of the mountains up to the Columbia River.

Begins to nest about Carson about the middle of May. After their arrival and during the early part of the summer, the orioles in this locality appear to obtain but very little of their subsistence among the trees, but resort in pairs to the hillsides, where on the ground among the sage bushes they appeared to glean a full harvest. The exact nature of this I did not ascertain; it is probably though some species of worm or caterpillar that infests these plants.

### SCOLECOPHAGUS Swainson.

*S. cyanocephalus* (Wagl.). Brewer's Blackbird.

This blackbird is extremely abundant throughout this whole region as a summer visitant, while more or less remain through the winter.

Elsewhere, as in the Rocky Mountains, I have found little disposition on the part of this species to gather into communities at the breeding season. But in this region it is comparatively unusual to find this blackbird breeding in other than large colonies, and I have found a dozen nests in the space of thirty or forty yards.

The eggs of no one of our birds are subject to greater extremes of variation than those of the Brewer's blackbird. The differences are apparent not only in the amount of markings and their particular shade and character, but also include much variation in size and shape.

## CORVIDÆ—Crows.

### CORVUS Linnæus.

The question of the existence in the Pacific province of a species or variety of crow different from *americanus* and *ossifragus* is an interesting one, and a discussion of some of the points involved will not be uninteresting, even if an entirely definite and satisfactory conclusion respecting the relationships of the eastern and western birds be not reached. The name *caurinus* was proposed by Professor Baird in 1858 for a crow inhabiting the northwestern coast, and specimens were cited from Puget Sound and Washington Territory. The characters of the supposed species rested mainly upon its smaller size, together with certain peculiarities of habits and notes. But from the first, the exact habitat and status of the new species appears to have been somewhat doubtful, as at the time of description the above author included under *americanus* a number of specimens from contiguous regions in California and Washington Territory, their distinctness from the newly-described *caurinus* being assumed entirely on account of their large size, no other differences being discernible.*

Since then the different habits and notes of the crows of the Pacific coast have been remarked in turn by nearly every observer who has visited that region, and appear to have been the main cause of the retention of *caurinus*, either as a distinct species or a geographical race of the common crow. In fact, habits and notes aside, no one appears to have been able to find a single tangible character by means of which the so-called *caurinus* was to be recognized.†

Thus Captain Bendire, in his list of Camp Harney birds, in which he gives *caurinus* as a "rare summer resident," remarks: "If it were not for their [that is, *caurinus* and *americanus*] totally different habits, I could see no really good reasons for separating this species."

Dr. Cooper seems to have been equally doubtful of the relations of *caurinus*, and says, in "Birds of California," "I am now satisfied that there is but one species of crow on this side of the continent, and, if distinguishable at all from the eastern, it is by its smaller size, less graduated tail, more gregarious habits, and different voice." In conformity with this view, he includes in the habitat of *caurinus*, not only the Pacific coast, but the region "east to the northern Rocky Mountains," thus entirely excluding *americanus* from the Pacific region.

Assuming the position taken by Dr. Cooper, that but one species of crow is represented upon the west side of the continent, I have been able, after a careful examination and measurement of all the material afforded by the Smithsonian collection, to verify the statement of the smaller size of the crows from the Pacific States *only as a slight average*, while among specimens from this region are some of the *largest* individuals I have seen—three, respectively from Tulare Valley, Southern California; Fort Crook, Northern California; and Camp Harney, Oreg., being matched in size by but few from the Eastern States. Nor do the strictly coast-inhabiting birds appear to be much, if any, smaller than those from interior districts. At least they are not constantly so, since Dr. Cooper says "the smallest specimens I have seen were collected by Mr. F. Gruber on the west slope of the Sierra Nevada, about latitude 38° 30′."

The shape of the tails of west coast specimens appears to vary in no particular from eastern, and I am fully convinced that it is in vain to attempt to separate the crows of California, Nevada, Oregon, and probably Washington Territory from *americanus* by definite and reliable external character, the range of that species, therefore, in my opinion, embracing the Pacific as well as the Central region.

But from the region north of Washington Territory the crows appear to undergo a general diminution in size, this being especially marked in respect to the length of tarsus; all the specimens at hand from the northwest coast (including one from Shoalwater Bay) agree in small size and extremely short tarsus. The general size of these birds is but little in excess of the average of *ossifragus*. But in no other particular are they like that species, being, in fact, save in the one particular of size, indistinguishable from eastern *americanus*. It was remarked by Professor Baird that the *Corvidæ* appear to form an exception to the general rule, and that "the same species in southern localities are larger than those from points farther north." This statement will require qualification in the case of *Corvus var. floridanus*, which, while averaging in general size a trifle smaller than Northern-born birds, yet offers, in the increased size of bill and feet, a marked contrast to them. But as applied elsewhere in the United States the statement appears to hold good, and especially on the other side of the continent, where a decrease of size with increased latitude appears to be the rule. Possibly this simple statement of fact is all that the difference in size exhibited by the crows of the extreme northwest requires.

As considerable stress has been laid upon the different habits of *caurinus* it may be well to consider these briefly; and, first, it is to be remarked that nearly all the differences in habits and notes appear to apply as well to the crows found throughout California, Oregon, and Washington Territory as to those of the region to the north, while, as has just been stated, it is only in the latter region that these are accompanied by a single salient character that will serve to identify the skins.

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* Prof. Baird further remarks of *caurinus*, after enumerating the points by which it may "readily be distinguished from the eastern fish crow," "it is so much like the *Corvus americanus* as to be only distinguishable by its inferior size and habits. Indeed, it is almost a question whether it be more than a dwarfed race of the other species."

† In the recent work, "Birds of North America," by Baird, Brewer, and Ridgway, a further distinctive feature is assigned to *caurinus*, viz, the fact that the tarsus is shorter than the bill. But this statement resulted from an incorrect method of measurement, as Mr. Ridgway now informs me, the tarsus being measured on its anterior surface, at the end of the feathering, instead of from the joint, thus giving a length too short by a very appreciable amount. With the exception of the diminutive Mexican species (*C. mexicanus*) all the North American crows agree in having the tarsus longer than the bill.

If habits be taken as the test, then all alike—those from the far interior of Oregon as well as from the coast, from California northward—must be held to be *caurinus*, although, as has been stated, a large proportion of specimens from Washington Territory southward absolutely differ in no particular of form or color from others from the Eastern States.

If, on the other hand, small size, as exemplified especially in the short tarsus, be held sufficient to characterize the race, then those only from north of Washington Territory are eligible to the name; and all from below, although sharing in the habits which have been held to distinguish *caurinus*, must be considered as *americanus*, notwithstanding, too, the additional fact that the measurements of some few of the smallest of these latter approximate somewhat closely to Alaska specimens.

It may be added that while observers agree in the general statement of the possession by the so-called *caurinus* of peculiar habits, the accounts of each vary as to the details, change of locality evidently producing a corresponding change in habits. Thus the domed nests, made of mud, which *caurinus* is said by Lord to build about Sitka, differ entirely from those found by Bendire in Oregon, and by Cooper in California, which resembled the usual style of the common crow. Nor do the piscivorous habits of *caurinus* offer anything very distinctive, since they are shared by the common crow of Florida (*var. floridanus*), which there has many of the ways of the true fish crow (*ossifragus*). About Washington, too, the common crow and fish-crow go in associate bands, and their notes alone can be relied upon to identify them as they feed together along the river. As further evidence of the varying habits of the crows, it may be stated that in this locality the fish crow in turn often abandons its usual littoral haunts for the plowed fields and pastures of the interior. In fact, with birds possessing the omnivorous taste of the crows it appears to be quite a matter of accident that determines their hunting grounds, those where food is most abundant and readiest at hand being the favorite; hence, of course, its nature varies indefinitely with locality and circumstances.

The alleged more pronounced gregarious habits of *caurinus*, even allowing all that is claimed, are probably but the result of exceptional conditions, and appear to be carried in the northwest but little farther than is observable in the common crow at the East. Even on the Pacific coast the habit of breeding in colonies is far from universal. When such colonies are formed they are as likely to be the result of necessity as of choice. As, for instance, when favorable breeding grounds are scarce, a more or less extensive colonization must necessarily follow, which is less marked when other conditions prevail.

As to notes, this much may safely be stated, that some, at least, of the crows of the Pacific province have a note different from the usual one of *americanus*. As Dr. Cooper says, this "differs rather in tone than in character." In other words, it is the old-fashioned caw, but uttered in a different tone. In Southern California, near the coast, and in Oregon, east of the mountains, I have on many occasions heard this note, which has strongly suggested that of *ossifragus*, and which I then took for granted as belonging to *caurinus*. But in every such instance the well-known ringing caws of *americanus* were recognized from the same flock. Of six or eight individuals shot from these flocks all proved to be indistinguishable from *americanus*, and at the time I presumed the particular individuals of *caurinus* must have escaped me. Now, however, I feel tolerably well assured that all alike were *americanus*, the notes varying in individuals. Mr. Ridgway, on the other hand, informs me that in his experience in the Sacramento Valley, Nevada, &c., he never heard any but the common note of *americanus*.

In conclusion, the general tenor of the change of habits of the Pacific crow, so far as any are to be noticed, is in the direction of the fish crow (*ossifragus*), and by at least one author the two have been regarded as identical. But in the proportions of certain parts and in colors they are very distinct from *ossifragus*, which may readily and infallibly be distinguished from the common crow from whatever locality by a number of well-defined characters.

At present I deem it, on the whole, advisable to recognize a race of the common crow from the extreme northwest coast, from Puget Sound northward, assigning, as characters, small size in general, and especially a short tarsus, at the same time admitting the possibility that a larger series from the region in question, together with additional data concerning habits, &c., may suffice to show its distinctness as a species. On the other hand, I am assured that no features are to be found attaching to the crows, either of the west coast or interior south of the above-mentioned point, that will warrant the maintenance of a name. They, at least, are *americanus*.

A series of measurements is appended below to afford means of comparison of the crows of eastern and western United States.

MEASUREMENTS.

| | Wing. | Tail. | Bill. | Tarsus. |
|---|---|---|---|---|
| AMERICANUS. | | | | |
| East of Rocky Mountains: | | | | |
| Average of 25 specimens | 12.36 | 7.24 | 1.85 | 2.39 |
| Largest individual (Massachusetts) | 13.00 | 7.45 | 2.00 | 2.60 |
| Smallest individual (New Mexico) | 11.50 | 7.00 | 1.72 | 2.25 |
| California and Oregon: | | | | |
| Average of 5 specimens | 11.78 | 7.21 | 1.78 | 2.30 |
| Largest individual (Fort Crook, Cal.) | 12.90 | 7.95 | 1.95 | 2.23 |
| Smallest individual (Stockton, Cal.) | 11.00 | 6.89 | 1.60 | 2.23 |
| VAR. CAURINUS. | | | | |
| Puget Sound, Alaska: | | | | |
| Average of 7 specimens | 10.82 | 6.68 | 1.70 | 2.00 |
| Largest individual (Puget Sound) | 11.60 | 7.25 | 1.88 | 2.12 |
| Smallest individual (Alaska) | 10.25 | 6.00 | 1.68 | 1.95 |
| VAR. FLORIDANUS. | | | | |
| Florida: | | | | |
| Average of 4 specimens | 12.05 | 7.12 | 2.04 | 2.49 |
| Largest individual | 12.50 | 7.25 | 2.10 | 2.50 |
| Smallest individual | 11.45 | 7.00 | 1.93 | 2.42 |

*C. carnivorus*, Bartr. American Raven.

A resident species; more or less common everywhere save in the higher mountain districts.

Pyramid Lake, Nevada, forms a favorite resort for ravens during the summer, as the perpendicular and inaccessible cliffs about certain parts of the lake present an abundance of sheltered ledges and cavities where they love to place their nests. I noticed that in one spot several pairs had built within the space of a few yards, a somewhat unusual circumstance, as ravens are not apt to be socially inclined at this period.

*C. americanus*, Aud. Common Crow.

Although by no means as generally distributed in the far West as in the Eastern States, the crow is yet found in probably each and all of the States and Territories west of the Mississippi. At all events it has not been wanting in any of those entered by our parties.

Whether its presence in the more remote Western States, as affirmed by many of the settlers, is a comparatively recent event, or whether the cultivation of the wilderness and the orchards and grain fields that have succeeded the advent of the pioneers have simply been the means of bringing the crow into direct contact with man, and so of making its presence felt, are questions not easy to determine. I am inclined to believe, however, that the crow had made good a squatter's right to the country long before the date of the white man's possession, and to attribute its present unquestionably greater abundance in sections and territories where at first it was unnoticed to the fact of the concentration of the species into civilized districts, where its sagacity soon taught it a living was to be had the easiest.

I have never heard laid to the door of the crow the charge of any serious depredations on the corn and grain fields of the new Territories, and fancy that the knavish tricks of its eastern cousins, that have earned them so bad a name, have not spread so far—possibly another reason for supposing that the western birds are not recent migrants from the east, else surely they had not left behind such profitable tricks as pulling up newly-sprouted corn and other devices of a like nature. Doubtless its natural food here is more abundant, and hence, the struggle for existence being less sharp, the crow finds it less needful to employ its wits to the end of getting a living at other folks' expense.

In Oregon, especially east of the mountains, crows are very numerous indeed, and I saw many large flocks on the various cattle ranges, as well as, later in fall, on the stubble fields. Meadowy pasture land and the vicinity of streams are the favorite resorts. The only difference between them and the "Jim Crow" of the east that I could detect was, at times, a difference in the cawing note, which, however, as stated above, seemed to attach only to individuals, the greater number in the various flocks holding to the old-fashioned caw.

The "smell for gunpowder" has evidently not been cultivated to the extent that is popularly attributed to the New England crow, and it proved a comparatively easy matter to obtain specimens. However, what crows, no matter where hatched, don't know about taking care of themselves is very soon acquired, and a very little experience will be found to go a long ways with them. Naturally the crow is no shyer than other large birds, and its extreme wariness at the East, instead of being an indication, as some writers are prone to construe it, of a natural trait, is simply due to persecution, and to it alone.

### PICICORVUS Bonaparte.

*P. columbianus* (Wils.). Clarke's Crow.

A constant and abundant resident of the pineries.

### GYMNOKITTA Maximilian.

*G. cyanocephalus* (Maxim.). Maximilian's Jay.

A numerous and constant resident of the low ranges of piñon hills. Along much of our route from Northern California northward along the base of the Sierra and Cascade Ranges this jay was entirely absent, the nature of the country being unsuited to its peculiar economy. At certain points in the Des Chutes Basin, however, it was noticed in great numbers. Here they were feeding upon a purple berry, the source of which I could not ascertain, but of which their crops were full, as well, too, upon the seeds of the yellow pine.

I am indebted to my friend Mr. H. G. Parker, of Carson, Nev., for an account of the nesting habits of this jay in his neighborhood. He informs me that late in March thousands breed upon the piñon hills, the colonies consisting of a variable number of pairs; occasionally isolated nests are found, but this appears to be rather exceptional. Eggs were taken April 10.

The single nest he has sent for examination shows an unexpected degree of taste and skill in the arrangement of the material, which is drawn very largely from the piñons. An external base of twigs, which appear to have been broken off from the ends of the branches, affords firm support for the nest proper, which is a compact, deeply hollowed cup, made of strips and shreds of bark from the sage bush. Finer strippings of the same with a few straws complete the lining.

The nest is usually placed near the top of the tree, sometimes near the extremities of the branches, occasionally close to the trunk. In any event it is but a few feet from the ground, for the piñon rarely indeed attains a height of twenty feet.

The coloration of the eggs is very peculiar, and they are unlike those of any other jay that I have ever seen. They are greenish-white, marked with numerous spots of brown and purple. As usual, this latter tint is due to the overlaying crust of shell, and is not, strictly speaking, a normal color. The markings are thickest at the greater ends, and tend towards aggregation in circles. A set of four eggs measure $(1.27 \times .87)^2$, $1.27 \times .88$, $1.27 \times .87$.

### PICA Vieillot.

*P. melanoleuca hudsonica* (Sab.). Magpie.

In the settled portions of Nevada and Eastern California of slight elevation, and especially in the wooded tracts that mark the courses of the streams, the magpie is a constant resident, and one which, from its size and general conspicuousness, is not liable to be overlooked. The thickets along the Carson River serve as favorite breeding grounds for great numbers of this species; in fact, I have never seen it more abundant than here.

As noisy and as easily irritated into vociferous demonstration as is the magpie under ordinary circumstances, no sooner has the breeding season fairly begun than, under influence of the new feelings and emotions that have sprung into existence, our magpie seems to lose its voice, and, from being one of the most garrulous of the feathered community, subsides into a very quiet and matter-of-fact sort of individual, as if perfectly aware of the danger its usual boisterousness is likely to bring upon its home. To prove that this quiet demeanor is but a cloak assumed for a season, in obedience to an instinctive apprehension of danger, it is only necessary to approach with too curious eyes the nest of one of a community of pairs, especially if it chance to contain young. Under such circumstances the intruder will find himself the target for imprecations and anathemas, delivered with such unction and effect from a dozen angry throats, that he will probably be glad to finish his investigations in a hurry and retire from the ground. In such a strait the pairs make common cause, and their audacity is in strong contrast to their usual wariness.

In the neighborhood of Carson every thicket of sufficient density to screen its bulky nest contains one, oftener several, of the structures, that are so characteristic as to at once proclaim their ownership.

While the magpie is to no inconsiderable extent a sharer in the natural cunning, so justly attributed to its relatives the crows, a fact in its history now and then comes to notice which would appear at first thought to negative the possession of this trait; as, for instance, the place and position in which their nests are occasionally found. Not only do these often seem to be imperiled by their proximity to the ground, being sometimes but a foot or two above it, but at times not the slightest attention will be paid to their concealment. I have in mind a certain point along the Carson River where some dead trees are found, in which the magpies have nested for apparently a long period, and where their nests are visible for a distance of many hundred yards. But as a matter of fact the eggs or young are less liable to danger than would at first thought be supposed, and doubtless experience has taught the birds this. In selecting sticks and twigs for the outer nest the magpie, probably by design, chooses such as, from their scraggly, thorny nature, they are enabled to so firmly interlock that all chance of forcible entry except through the small aperture in the side left for the purpose is cut off, and every foe provided against except man alone. Indeed, I have myself, more than once, found it a far from easy matter to gain the interior through this thorny barrier.

So far as humans are concerned the magpies have but little to fear, as their marketable value, fortunately for themselves, amounts to next to nothing. For, notwithstanding the fact that they may, when taken in hand young, be readily tamed and, after the proper manipulation, be taught to talk, they are so noisy and their dispositions so extremely mischievous, that a short experience usually results in their being voted a nuisance, and hence they stand in low favor. So a few taken for pets and an occasional nest destroyed by mischievous boys sum up the dangers of the magpie's housekeeping.

The labor of this is pretty evenly divided. Upon the females devolves the main task of incubation, relieved now and then by their partners. The latter are away from home most of the time busily occupied in foraging, since not only have they their own appetites to appease, but it is their duty to provide for the females engaged in their enforced duty. Upon the appearance of the young both birds share equally in attention to their wants.

About Carson the eggs are not deposited before the 1st of March, but as late as the 12th of May quite a number of nests were found to contain fresh eggs.

### CYANURA Swainson.

*C. stelleri frontalis*, Ridgw. Blue-fronted Jay.

This form of the Steller's jay has been traced by the expedition from the Coast and Sierra Ranges of Southern California into the Cascade Mountains of Oregon, and so on up to the Columbia River, at which point, however, the form does not cease, but continues into Washington Territory.

As is well known, this bird is represented in the Rocky Mountains by the long-crested variety, in which the streaks of the forehead are of a faint bluish-white instead of blue, and the upper eyelid is conspicuously patched with white. Two specimens collected at the base of the Cascade Range are worthy of note in this connection, since, while they represent the normal *frontalis* type in every other particular, both show unmistakable traces of this white patch, which in one is quite conspicuous; a hint, as it were, of the new character to be assumed farther to the eastward.

A description of the young in first plumage is subjoined.

*First plumage.*—Above, dark plumbeous; head darker, *with no trace of blue streaks* on forehead; wings blue, barred with black, as in adult; belly light blue; breast and throat plumbeous; chin with light space.

### CYANOCITTA Bonaparte.

*C. floridanus californicus* (Vig.). Californian Ground Jay.

Numerous in the brushy foot-hills to a considerable distance north of Carson, Nev. A single specimen, the only one seen, was taken at The Dalles, on the Columbia, October 4, and it perhaps occurs here and there over the intervening ground.

Nuttall found the species common at Fort Vancouver, on the west side of the Cascade Mountains, in October, and indicates its occurrence as far north as the Frazer's River. This was in 1834, and it appears to have escaped the observation of all the more recent explorers of the same region. Recently Mr. C. Roop, of Portland, Oreg., informed me that this jay is abundant near the mouth of the Willamette River, in both Oregon and Washington Territories.

All the specimens we have seen from along the western slope, although not typical of the above race, are best referable to it.*

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*In which connection see annual report of this survey for 1877, p. 1305.

A description of the first plumage of this form is added from a fledgeling taken at Eagle Lake, California, in July.

Prevailing color above, plumbeous brown; head with bluish cast; wings and tail blué, as in adult; below ashy white; feathers on throat and breast showing no traces of streaks; sides of head and an imperfect bar across breast dusky plumbeous. A conspicuous white line above and behind the eye.

### PERISOREUS Bonaparte.

*P. obscurus*, Ridgw. Oregon Gray Jay, "Meat Bird."

This bird was not recognized as distinct from the Canada jay (*P. canadensis*) until quite recently, when Mr. Ridgway described under the above name specimens from Shoalwater Bay, and indicated Washington Territory, Oregon, and the northwest coast generally as its habitat. Mr. Ridgway, however, included the form under head of *canadensis*, presuming it to represent the Pacific coast variety of that bird, as *capitalis* does the Rocky Mountain form.

A recent investigation, in connection with Mr. Ridgway, of a better series of specimens than was available when *obscurus* was described, leads to the belief that this form is entirely distinct from the Canada jay, its peculiarities being of a kind not explainable upon any theory of geographical variation. As good descriptions of *obscurus* are found elsewhere, I need here merely allude to its chief distinctive points, viz: the conspicuous white shafts of the feathers of the back and scapulars, and the ashy white under parts, tending to brown only along the sides. In these particulars it differs conspicuously from the others.

During the past season *obscurus* was found to be a resident of the mountains from Northern California to the Columbia River, its range being thus extended very materially. The young in nesting plumage were taken near Camp Bidwell, California.

My specimens from the above region agree with the types in essential respects; in fact the only difference appears to be in regard to the amount of white, especially on forehead, it extending farther back towards the occiput than in the coast examples, while the general tints also are lighter.

A comparison of specimens of the Canada jay from Alaska and Maine reveals considerable difference. In fact, extreme examples of the Alaska type appear to show peculiarities of color sufficient to warrant their separation as a variety. Even, however, in the small series from the former region in the Smithsonian collection, there is a very noticeable amount of purely individual variation, and some specimens cannot be discriminated from Maine examples. So that, on the whole, I do not consider the difference sufficient to justify a new name.*

That the Rocky Mountain form *capitalis* intergrades completely with *canadensis* there can be no doubt, although typical specimens of *capitalis* offer very tangible differences. In the northern Rocky Mountains, as in Montana, the peculiarities of this race very sensibly diminish, and the tendency towards the *canadensis* type is marked. From farther south and in its region proper, no specimens appear to be found which are not wholly characteristic of *capitalis*.

The following measurements express the variations in size between the forms:

| | Wing. | Tail. | Bill. | Tarsus. |
|---|---|---|---|---|
| *P. canadensis*: | | | | |
| Average of 6 specimens | 5.61 | 5.93 | .75 | 1.35 |
| Largest individual | 5.84 | 6.07 | .83 | 1.45 |
| Smallest individual | 5.33 | 5.54 | .73 | 1.33 |
| Alaska specimens, *P. canadensis*: | | | | |
| Average of 7 specimens | 5.43 | 5.66 | .77 | 1.33 |
| Largest individual | 5.67 | 5.65 | .85 | 1.40 |
| Smallest individual | 5.10 | ........ | ........ | 1.26 |
| Var. *capitalis*: | | | | |
| Average of 10 specimens | 6.04 | 5.99 | .80 | 1.36 |
| Largest individual | 6.35 | 6.12 | .82 | 1.40 |
| Smallest individual | 5.72 | 5.55 | .73 | 1.34 |
| *P. obscurus*: | | | | |
| Average of 7 specimens | 5.53 | 5.38 | .71 | 1.31 |
| Largest individual | 5.78 | 5.58 | .69 | .321 |
| Smallest individual | 5.23 | 5.12 | .72 | .261 |

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* Since the above was written Mr. Ridgway informs me that he has given the name *fumifrons* to the Alaskan coast form.

As will be noticed, Alaska specimens appear to average considerably smaller than those from Maine.

Var. *capitalis* undergoes a decided increase in length of wing, without a corresponding increase in size of tail.

In *obscurus* the proportions of wing and tail are reversed, it being the only one which has the tail shorter than the wing.

*Habits.*—As Northern California is reached, the Oregon gray jay becomes a familiar object of attention in the pine woods, of which it is a constant resident. Along the Upper Des Chutes River the "meat birds," as they are suggestively termed by the hunters, were very numerous; so numerous, in fact, and so quietly persistent in their attendance about the cook-fire, that they became positive nuisances. When they are inclined towards familiarity, they carry their boldness to a surprising extent. Every morning about sun-up, from six to a dozen or more presented themselves in the trees overhanging camp, and the momentary absence of the cook from his charge was construed as an invitation to the feast, and down they swooped upon the nearest morsel of food. Almost everything edible seemed to be acceptable, although their preference for raw meat was plainly evidenced. Finally, when the cook's patience gave out, the shotgun was brought into requisition, which diminished the number, without having any visible effect in checking the rapacity of the survivors. Several were readily caught by means of a bent pin fastened to a string and baited with scraps of venison. They are not always by any means so bold as in this locality, and a dark form, visible for an instant as it flits noiselessly through the sombre pines, is often the only proof of the presence of the species.

I have always found the Rocky Mountain gray jay to be a very silent bird. But this species has a variety of odd notes, a sort of squeaking, whining call being the most common. Cooper also assigns this species a "considerable variety of song."

## TYRANNIDÆ—Tyrant Flycatchers.

### TYRANNUS Cuvier.

*T. verticalis*, Say. Arkansas Flycatcher.

A very numerous summer resident. It was not observed by us farther north than Southern Oregon, but doubtless this was owing to the lateness of the season, as it was found by Suckley at The Dalles, and even farther north in Washington Territory. The *T. carolinensis* was not met with, but, according to Mr. Ridgway, occurs in summer in Western Nevada (Truckee Valley).

### MYIARCHUS Cabanis.

*M. cinerascens* (Lawr.). Ash-throated Flycatcher.

Common on the foot-hills near Carson, but apparently a rare summer visitant farther north along the eastern slope. A single individual was seen at Honey Lake, California.

### SAYORRNIS Bonaparte.

*S. sayus* (Bp.). Say's Flycatcher.

Numerous along the eastern slope. This species is in the habit of building about barns and outbuildings, in this respect being like the eastern Phœbe. A curioust nesting site selected by one pair was a little niche in the sandy wall of a disused well, and some twenty feet or more from the top. The problem of getting the young up the old birds had yet to solve.

The *S. nigricans* appears not to be present in this region, although it is common to the west of the mountains in Oregon.

### CONTOPUS Cabot.

*C. borealis* (Sw.). Olive-sided Flycatcher.

This flycatcher occurs in summer all along the eastern slope up to the Columbia River, and probably still farther to the north. It does not appear to be as numerous here as in the Rocky Mountains, or even in the region west of the Sierras.

*C. virens richardsoni* (Sw.). Western Wood Pewee.

A common summer visitant of the mountains. A nest found June 26 contained two eggs somewhat advanced.

This flycatcher appears to vary the position of its nest, sometimes building in the fork of a limb, at other times placing it on the broad upper surface—in other words, saddling it. The same variation in plan is observable in the nests of our eastern pewee, although in both, the latter method seems to be the favorite.

The nest alluded to above, as also a second found July 23, was saddled upon the terminal fork of a cottonwood, and was similar to the usual style of the eastern pewee, except that the exterior lacked the customary sprinkling of lichens given it by the latter bird. Instead it was dressed with shreds of a white cottony substance and gray fibrous bark, which served admirably to harmonize its tints with those of the light bark of the tree, precisely the same end being thus attained as effected by the other bird, each using the material best adapted to its own case. It would indeed be a "blind" instinct that should induce the western pewee to adopt for its nest the cloak of lichens, the invariable and successful resort of its eastern relative, an instinct that would prove fatal to the safety of its home, and only serve to invite the very danger of conspicuousness which it is its chief object to avoid. The contrast of differing means to the same end which is displayed in the architecture of these two flycatchers is one of many equally good illustrations which might be cited to prove the presence in birds of a something higher than mere hereditary instinct, and shows that only by granting the existence of an amount of reasoning power can we explain the readiness with which a species adapts its existence to new conditions, and the fertility of resource which prompts the choice of means to a necessary end.

### EMPIDONAX Cabot.

*E. trailii*, Aud. Traill's Flycatcher.

Western specimens of this bird have usually been considered to represent a light-colored race, and have found mention under name of *var. pusillu.* I think Mr. Ridgway is correct in the view recently expressed,* and that western and eastern birds do not differ sufficiently to warrant their separation.

The *pusillus* of Swainson was accepted by Professor Baird as applying to the western bird, but apparently with some doubt, as Swainson's description applies almost equally well to *minimus.* I prefer, therefore, to fall back upon the *trailii* of Audubon, including under this name both eastern and western birds.

The Trails flycatcher is a numerous summer resident of the eastern slope, well up into Oregon. It loves to frequent the willow thickets along the streams, even following them to a high elevation in the mountains.

*E. obscurus* (Sw.). Wright's Flycatcher.

Apparently rather uncommon as a summer inhabitant of the mountains, where only it is found at this season. It appears in summer never to frequent the same situations as the preceding bird, although the two may inhabit the same general locality. Thus, the borders of a stream which meanders through an alpine valley, and which is hedged by willows, will be found, almost to a certainty, to be inhabited by the little flycatcher, while the present species never intrudes on the domain of this bird, but is contented with the hillsides above, where it lives under the pines and among the chaparral.

It would be interesting to study out the probable causes which thus lead two species so closely allied as these two flycatchers, with the same general habits and economy, with precisely the same method of capturing food, and living within sight, as it were, of each other, to so maintain their own preserves as never to clash with each other. A possible explanation suggests itself in varying tastes as to food, since it is probable that each locality differs enough in the character of its plants to harbor different kinds of insects, and hence to furnish each species with its own particular bill of fare.

A nest found June 22 contained four fresh eggs. These are yellowish-white, and unspotted. The nest was an extremely neat, pretty structure, composed externally of strips of white bark, with an internal lining of fine grasses and feathers. It had a depth of two inches, and an internal diameter of the same. It was singularly exposed to view, being placed on an open bush on a hillside, where it was overshadowed by large pine trees.

The *E. hammondi* is said to also occur along the eastern slope, but I did not meet with it.

## CAPRIMULGIDÆ—Goatsuckers.

### CHORDEILES Swainson.

*C. popetue henryi*, Cass. Western Night Hawk.

An extremely abundant summer visitant through California, Oregon, and into Washington Territory.

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* Ornithology of the Fortieth Parallel, page 539.

Several sets of eggs were found, which seemed to have been deposited on the ground hap-hazard, with little or no attention to special locality.

### ANTROSTOMUS Gould.

*A. nuttalli*, Aud. Nuttall's Poorwill.

In the neighborhood of Carson the poorwill arrives from the south in the early days of May. It soon becomes generally and commonly distributed over nearly all the region embraced in the present report, being scarcely less numerous towards the north. Both Cooper and Suckley note its presence in the portions of Oregon and Washington Territory, east of the mountains, and indicate negatively its absence to the west.

## TROCHILIDÆ—Humming Birds.

### STELLULA Gould.

*S. calliope*, Gould. Calliope Humming Bird.

The range of this diminutive humming-bird is now pretty well made out. It has long been known as a resident of the west coast, and there extends over much of California, Oregon, and Washington Territory, where in summer it is confined to the mountains. To the eastward its summer habitat appears to be in general limited by the eastern slope, along which, in Nevada, California, and Oregon, it was found by our parties to be very numerous. In fall, at least, it reaches as far into the middle region as the East Humboldt Mountains, where found in August by Mr. Ridgway. New Mexico and Arizona, as determined by our parties, complete its limited range in the central regions and likewise its known dispersion within our limits. It may breed in the latter Territories, as specimens were obtained in July. That it does so along the eastern slope there is no possible doubt, as about the middle of June, in Eastern California (Honey Lake), I often saw the females most busily at work gathering stores of down from the willow catkins, then hanging full, to weave into nests. I was left to conjecture that the location of these was in the high branches of the firs and other evergreens, as I failed to discover a single one, which could hardly have been the case had they been in positions at all accessible.

The males were at that season very restless and wary, and to procure specimens proved no easy matter. The flower which here is most resorted to, not alone by this but by other hummers, is a species of *Castilleia* which is found along the banks of most all the mountain streams. Wherever these blossoms are numerous, the hum of wings of these busy little pilferers as they dart to and fro is constant.

Humming-birds have, however, in this section, another and less usual source of food supply, to which my attention was attracted while in the mountains near Camp Bidwell. For several of the early hours of morning I noticed that the humming-birds hovered about the upper branches of the firs and spruces, precisely as if feeding, to the entire neglect of the flower-bordered streams which occupied their attention later in the day. As this is the time when they are hungriest, I could only account for their actions on the supposition that they were feeding upon "honey dew." As this may not be familiar to all my readers, I will state that it is a sweet saccharine substance that is deposited upon the foliage of trees and shrubs in many localities of this region by certain small insects, the plant-feeding *Aphides*. It is often found in considerable quantities, so considerable in fact that in some places, as I was informed, the Indians collect it by threshing the plants after the sun has evaporated it into a sugar, and make use of it as food. That it is sweet and palatable, I myself can testify, and doubtless as much so to the delicate taste of the humming-birds as to the human palate. In early morning, before the sun's rays have evaporated it, "honey dew" is found in a semi-liquified state, and then would be as easily managed by the brush-tipped tongues of the birds as the nectar of flowers. Without doubt, too, the birds secure many small insects which resort to feed upon this substance.

Here I wish to notice what I believe was an error of identification on the part of Dr. Cooper when he mentioned the broad-tailed humming-bird (*S. platycercus*) as common at Lake Tahoe in September.* This is quite out of the area of the known distribution of that bird, which is distinctively a central region species. *Stellula*, on the other hand, is a common summer resident of this region and could scarcely have been overlooked. It is not, however, mentioned by him from that locality. Hence I infer that his specimen of supposed *platycercus* was really the *Stellula*, more especially because he appears to have been in doubt, and states that at first he supposed the species to be *S. rufus*. In this latter supposition he may have been correct, but as, farther on, when speaking of the Stellula as seen in the Cascade Mountains, he says he there mistook that species for the young of *S. rufa*, we may presume his mistake to have been the same in both instances, and that the Lake Tahoe birds were the *Stellula*, as the Cascade Mountain birds proved to be. It is to be remarked that the young of several of the hummers are really so much alike, especially those of *calliope* and *rufus*, that a very careful comparison, which is rarely possible in the field, is necessary to distinguish them.

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* Birds of California, vol. 1, 1870, p. 357.

### Trochilus Linnæus.

*T. alexandri*, Bourc. and Muls. Black-chinned Humming Bird.

This species appears to be a by no means common summer resident along the eastern slope, and to have there a limited distribution. It was observed and specimens were procured in June in Eastern California along Honey Lake. Farther north, in the mountains near Camp Bidwell, the species was present in July.

### Selasphorus Swainson.

*S. rufus*, (Gmel.). Rufous-backed Humming Bird.

This hummer is probably rather local as a summer resident of the eastern slope. In the summer of 1876 I did not find it breeding in Eastern California, although plentiful enough there in fall. It appeared to be rather numerous in summer near Camp Bidwell.

## ALCEDINIDÆ—Kingfishers.

### Ceryle Boie.

*C. alcyon* (L.). Kingfisher.

Of common occurrence on all the fish-stocked streams.

## PICIDÆ—Woodpeckers.

### Hylotomus Baird.

*H. pileatus* (L.). Pileated Woodpecker.

The "log cock" was not noted by our party at any point along the eastern slope, notwithstanding that the heavily timbered mountains would appear to favor its presence. On the Columbia, to the west of the divide, it was said by the lumbermen to be a numerous and constant resident. I shot a fine male, the only one seen, at the Cascades, in October.

### Picus Linnæus.

*P. villosus harrisi* (Aud.). Western Hairy Woodpecker.

Numerous as a resident of the pineries.

*P. pubescens gairdneri* (Aud.). Western Downy Woodpecker.

Along the eastern slope, as everywhere throughout the middle region, this is a rare species, and but a single individual was seen—in Chewaucan Valley, in August.

*P. albolarvatus* (Cass.). White-headed Woodpecker.

This woodpecker appeared to be less common everywhere along our route to the north than in the pineries immediately west of Carson. It occurs nevertheless here and there as a resident.

### Picoides Lacépède.

*P. arcticus* (Sw.). Arctic Woodpecker.

A rather common and constant resident of the pine woods from Carson northward into Oregon.

### Sphyrapicus Baird.

*S. varius nuchalis* (Bd.). Red-naped Woodpecker.

This middle region form extends across from the Rocky Mountains, and occurs in summer along the eastern slope. Beyond this we have no evidence of its presence, it being replaced upon the west coast by the following bird.

Mr. Ridgway alludes to the fact that in the region between the Rocky Mountains and the Cascade Range specimens of this form give evidence, by the admixture of red in the black auricular stripe, the black pectoral collar, and in the white area surrounding it, of the change soon to result in the variety *ruber*, in which these parts are red. Two males, however, taken in the Warner Mountains, Northern California, show no such tendency, but, on the contrary, are not distinguishable from Rocky Mountain specimens.

*S. varius ruber* (Gm.). Red-breasted Woodpecker.

Somewhat to my surprise I was able to obtain no evidence that this variety summers along the eastern slope, and am compelled to believe that it is only found here in the character of a fall and winter visitor.

*S. thyroideus* (Cass.). Brown-headed Woodpecker.

Of rather frequent occurrence all through the mountains.

### ASYNDESMUS Coues.

*A. torquatus* (Wils.). Lewis Woodpecker.

Nowhere in its wide range is this species more abundant than at the base of the eastern slope, through Nevada, California, and Oregon. It was seen at The Dalles during the last of October, and according to Suckley it remains here during the winter.

### COLAPTES Swainson.

*C. auratus mexicanus* (Sw.). Red-shafted Flicker.

An abundant and widely-distributed species. The birds of the eastern slope appear to be the typical *mexicanus*, and I have never seen a specimen from this region showing intermediate characters. In the Sacramento Valley and about San Francisco such specimens are comparatively common, and the manner and degree in which individuals assume the characters of either race vary indefinitely.

## STRIGIDÆ—Owls.

### STRIX Linnæus.

*S. flammea americana* (Aud.). American Barn Owl.

Though a very common inhabitant of California, especially in the southern portion, and extending, according to Cooper, as high as the Columbia River, this owl appears to confine its range, so far as this region is concerned, to the country west of the Sierras, and it does not appear in any of the sectional lists east of that range between Kansas on the east and Arizona on the south. That it does occur on the east side of the Sierras I obtained ample proof during the past season. Near the Madeline Plains in Eastern California I found scattered feathers of barn owls, indicating that they inhabited the thickets along the streams. At Camp Bidwell it seemed to be a tolerably common species, and on several occasions individuals were started up as they were roosting among the tangled willows. This was late in September. It also appears to be of at least occasional occurrence in Western Nevada, and Mr. H. G. Parker has information of the capture of a specimen or specimens near Carson.

It is one of the most strictly nocturnal of the family, and as its diurnal retreats are usually of the most inaccessible character, the bird readily eludes casual observation. Hence it is likely to prove to be more widely diffused in the interior province than we are at present aware.

### OTUS Cuvier.

*O. vulgaris wilsonianus* (Less.). Long-eared Owl.

Numerous in the thickets of the lowlands, where it is resident throughout the year.

*O. brachyotus* (Stev.). Short-eared Owl.

This owl was found to be common in the sedgy marshes about Warner Lake, Oregon, and doubtless inhabits similar localities throughout Eastern California and Nevada.

### BUBO Dumeril.

*B. virginianus sub-arcticus* (Sw.). Western Great Horned Owl.

Often heard in the mountains, where it is resident. Two individuals of the many seen were obtained in the Cascade Mountains. They represent the common interior type.

### SPEOTYTO Gloger.

*S. cunicularia hypogæa* (Bp.). Burrowing Owl.

Numerous in all suitable localities through this region.

## FALCONIDÆ—Hawks, Eagles, etc.

### CIRCUS Lacépède.

*C. cyaneus hudsonius* (L.). Marsh Hawk.

Very numerous in every suitable locality.

### ACCIPITER Bonaparte.

*A. fuscus* (Gm.). Sharp-shinned Hawk.

A single specimen only of this hawk was obtained, at the Columbia River, in October.

*A. cooperi* (Bon.). Cooper's Hawk.

Appears to be much more numerous in this region than the preceding. Seen on the Columbia in October.

### ASTUR Jard. and Selby.

*A. atricapillus* (Wils.). American Goshawk.

This fine hawk was seen at several points along the Cascade Mountains in Oregon, where it, without doubt, breeds.

I had very little chance to observe its habits; probably they do not differ essentially from those of its smaller relatives. One that I shot on the Williamson's River was in hot chase of a kingfisher, which he doubtless would have seized in another moment. Another, on the same river, was noticed chasing a night heron. The attack was persistently kept up, but evidently with no intention on the part of the hawk of making the heron his prey. Forcing the heavy-winged heron into the open, the hawk would close in and apparently give the ungainly bird a buffet with his wing, which each time produced a loud and discontented squawk. It occurred to me, as a possible solution of the motive of the hawk, that he intended to force his victim to throw up any fish it might have secured, and so furnish him an easy dinner.

### FALCO Linnæus.

*F. lanarius polyagrus* (Cass.). Prairie Falcon.

A widely-diffused species, and common in certain localities of this region, as near Camp Bidwell.

In the fall its habits as truly entitle it to the appellation of "duck hawk" as its relative the *F. anatum*. The latter, although not falling under our observation, certainly occurs in this region, but by no means as commonly as its ally.

*F. richardsoni.* Richardson's Falcon.

The presence of this falcon was noted in several localities in Oregon and Northern California, and two specimens in immature plumage were taken.

*F. sparverius* (L.). Sparrow-Hawk.

Very common throughout this whole region.

The west side of Chewaucan Valley had suffered severely from a visitation of that scourge of the western farmer, the grasshoppers. Here in August the sparrow-hawks had assembled in hundreds and were holding high carnival, and although in instances like the present their numbers prove wholly insufficient to cope against the vast myriads of these destructive insects, yet the work of the sparrow-hawk is by no means so insignificant that it should not be remembered to his credit and earn him well-merited protection. His food consists almost entirely of grasshoppers when they are to be had, and as his appetite appears never to become satiated, the aggregate in numbers which are annually destroyed by him must be enormous.

### BUTEO Cuvier.

*B. swainsoni* (Bp.). Swainson's Hawk.

Very numerous in summer in the low partially-wooded country near the mountains. I noticed more of these hawks in Northern California than farther south, but this increase in numbers may have been only apparent, and due to their concentration as fall approached.

*B. borealis calurus* (Cass.). Western Red-tailed Hawk.

Numerous throughout all the heavily-wooded portions of the region.

### ARCHIBUTEO Brehm.

*A. ferrugineus* (Licht.). California Squirrel Hawk.

A hawk was seen in Northeastern California which I believed to be of this species.

*A. lagopus sanctijohannis* (Gmel.). Rough-legged Hawk.

Common in fall in marshy localities.

### AQUILA Brisson.

*A. chrysaëtos canadensis* (L.). Golden Eagle.

Occurring more or less numerously among the mountains.

### HALIAËTUS Savigne.

*H. leucocephalus* (L.). American Eagle.

This eagle may fairly be said to abound on certain of the mountain lakes of this region, Eagle Lake indeed receiving its name from the number of these birds that inhabit its shores. Rarely disturbed, they are much less shy than usual, evidence of this fact being apparent in the accessible situations which their nests occupy. Several were noticed in the splintered tops of pines, the low heights and convenient branches of which placed them within easy reach.

One nest that I visited as late as July 10 contained two young, still unable to fly, though in size fully grown.

Along the Columbia, eagles are so common that they scarcely attract attention. Here they are useful as scavengers, and dead and dying salmon form a very considerable portion of their fare.

### PANDION Savigne.

*P. haliaëtus carolinensis* (Gmel.). Fish Hawk.

Present on nearly all the streams and lakes that furnish fish. Extremely abundant at Klamath Lake.

## CATHARTIDÆ—American Vultures.

### RHINOGRYPHUS Ridgw.

*R. aura* (L.). Red-headed Vulture.

Generally distributed; in some localities, as near Honey Lake, California, very numerous. Not seen at the Columbia River in October. Nor was the Californian vulture (*Pseudogryphus californianus*) observed along the river, although, judging from the accounts of Cooper and Suckley, it formerly periodically visited its shores, attracted thither by the dead salmon, which, during the "run," often line the banks. The accounts of these authors date back to 1854, and since that time the numbers of this huge vulture have been so diminished by the use of poison, intended to kill off wild animals, that it is now in comparison almost extinct, and the sight of a California vulture is at present a rare event in localities where a few years ago it was very numerous.

## COLUMBIDÆ—Doves.

### ZENAIDURA Bonaparte.

*Z. carolinensis* (L.). Turtle Dove.

Arriving in the vicinity of Carson about the 1st of May, the "doves" soon become extremely numerous, not only here but all along the eastern slope, far up into Oregon and Washington Territory.

By the game law of Nevada this species is exempt from protection at any and all seasons, and as it is about the only bird here that affords wing-shooting, it hence, in the neighborhood of the towns, receives considerable attention at the hands of the gunners, especially during the early portion of its visit in spring.

It begins to nest about the middle of May, and then its persecution perforce ceases, since it no longer resorts to the stubble-fields and pastures for food, but, having paired, retires to the hills, where it is out of reach.

The numbers killed, although in some sections very great, appear to have no visible effect in diminishing its abundance.

It migrates south early, and but few are to be found in Nevada by the end of August. As late as the 23d of September I noticed a few young birds, probably the late second broods, still lingering about the stubble along Crooked River, Oregon.

### COLUMBA Linnæus.

*C. fasciata* (Say). Band-tailed Pigeon.

At The Dalles I caught a glimpse of a solitary individual which I identified as this species. It is said by both Cooper and Suckley to be abundant to the west of the mountains, and doubtless wanders across the range with greater or less frequency, the abundance or scarcity of food, especially acorns, having much to do in determining its presence or absence in a region. Dr. Newberry speaks of it as occurring at The Dalles in fall.

## TETRAONIDÆ—Grouse.

### CANACE Bonaparte.

*C. obscurus* (Say). Dusky Grouse.

The "blue grouse," which is found in the Sierra and Cascade Ranges, at least along their eastern slopes and as high up as the Columbia River, is the typical middle region form, *obscurus*.

The mountain forests, especially those composed largely of firs and spruces, abound with this fine game-bird. Several broods of young chicks were found about the middle of June.

*First plumage of young.*—Feathers of the back and wings (except primaries) with broad central line of white, and marked transversely with spots and bars of black and rufous brown; throat and belly brownish white; breast and sides of body profusely maculated with black.

### CENTROCERCUS Swainson.

*C. urophasianus* (Bp.). Sage Hen.

Numerous as is this species in many portions of the Rocky Mountain region, it appears to be even more abundant in the sterile tracts that lie just east of the Sierra Nevada and Cascade Ranges, where it is generally diffused in all suitable localities from a point well up towards our northern boundaries to as far south as the Mojave River where reported by Cooper. The most southern point at which the bird was encountered by our parties was about fifty miles south of Carson, as indicated by Lieutenant Macomb. Somewhat to the north of here it begins to be very numerous, and in certain localities, as near old Camp Warner, Oregon, its numbers are simply astonishing. A day's ride through this section in almost any direction will reveal band after band, many containing numerous individuals.

During the summer it inhabits preferably the low mountains and hills, which are only saved from utter barrenness and destitution by a growth of sage or brush of similar kind and a scanty covering of coarse grass. The little valleys intervening contain occasional springs, which with the surrounding plats of green verdure form little oases, and these are the centers around which congregate, at least thrice a day, all the sage-hens within a considerable area. When making the usual night's camp we have often started up fifty or more of these big grouse almost within stone's throw of the solitary pool of water. At midday, too, flocks of old and young love to come in from the sterile tracts where they have been feeding, to drink and bathe and repose in the grateful shade which they find only in such spots.

After the young are able to run about, I believe the mother bird assumes sole charge over them, and that the old cocks assemble into bands and remain by themselves. I have on several occasions seen a dozen or more old males, lean in flesh and with plumage soiled and worn, thus associated. The old cock, under such circumstances, is a wary bird and knows well how to take care of himself. Little need, however, has he of his caution, since his toughness and general unsavoriness will be likely to cause anyone who once has made his acquaintance on the table to give him a wide berth in the future. But it is some time ere the young learn fully the necessary lesson of caution and self-dependence, and even after they have become almost fully grown they may frequently be put up one by one and killed without causing the dispersion of the rest of the band.

In fact, the tameness of the sage hen when, say, two-thirds grown, is occasionally so remarkable as to appear scarcely credible. As an instance, I remember on one occasion, when in one of the wilder districts of Oregon, pointing out a pair to a comrade, who had expressed a desire to try a shot on the wing at this, to him, new game. Unscreened by cover, the pair permitted him to approach within a dozen feet or so, regarding with mild wonder his demonstrative motions, and even failing to take alarm when dirt and pebbles were tossed at them. With the remark that they were too slow game for him, my disgusted friend left them to resume their picking among the herbage, which they did while we were still regarding them.

During the months of June, July, and August the young are very tender, and, if properly attended to by being drawn as soon as shot, are fair eating, but this is the limit of praise that my taste, at least, will permit me to bestow.

### PEDIŒCETES Elliott.

*P. phasianellus columbianus* (Ord). Southern Sharp-tailed Grouse.

This grouse appears to be entirely absent from Eastern California and Western Nevada, except in the upper districts. About Camp Bidwell, Cal., the "sharp-tails" are sufficiently numerous to afford excellent shooting, and good bags may be made there. Farther north in Oregon, and especially on the grassy plateaus that border the Columbia River and on the rolling hills for a hundred miles south, it is extremely abundant. Most of this section is quite uncultivated, and the grouse live among the dry hills and get fat upon their natural food of seeds, berries, and insects. They descend regularly into the valleys, as well to get water as to roost in the brush at night. A stubble-field of wheat is sure to attract them in great numbers, especially towards fall, and they seem to prefer this fare to aught else.

I have never had any experience in the field with the true prairie chicken (*C. cupido*), but, judging from the written accounts, the general habits of the two birds are extremely similar.

### BONASA Stephens.

*B. umbellus sabinii* (Dougl.). Red Ruffed Grouse.

This form of the ruffed grouse occurs abundantly along the eastern slope, although perhaps not until Oregon is entered. At least, Fort Klamath was the first point at which I obtained undeniable proof of its presence.

It may here be remarked that the grouse of this region, while referable as above, do not typically represent the variety *sabinii*, which reaches its maximum of development, as indicated by depth of color and redness of tint, only on the Pacific slope.

In the dense coniferous forests that border the Columbia, as it passes through the Cascade Mountains, these grouse are found in very great abundance, the almost impenetrable undergrowth of deciduous bushes, with their nutritious fare of buds and berries, greatly favoring its presence, as offering both food and cover.

It is scarcely necessary to add any details respecting the habits of this bird; for in this remote region it appears the exact counterpart of the familiar partridge of New England. True, they are here very tame and almost devoid of fear of man; so tame are they, in fact, that without a dog it is well nigh useless to attempt their pursuit. Provided with almost any sort of a cur that will run through the bushes and bark when the birds wing their way to the nearest tree, which they will invariably do when started, almost any desired number may be potted; for "pot hunting" it is, and nothing else.

Much the same statement may be made of the conduct of the ruffed grouse in the more remote New England districts, as in some unfrequented parts of Maine; so, with a statement of general conformity of habits, the subject may be left.

## PERDICIDÆ—Quails.

### OREORTYX Baird.

*O. pictus* (Dougl.). Mountain Quail.

Judging from the personal field experience of the past three seasons, this fine gamebird is much more numerous within an area of twenty-five miles of Carson than anywhere to the northward. In fact, it is only at rare intervals that it appears to cross the mountains and appear along the eastern slope. Evidence upon this point is not so full as could be desired, since its introduction at the hands of man at certain points renders the question of its natural distribution in this region a difficult one to determine. In general, it is safe to say that the places where they have reached and maintained a residence along this slope are very few. Nevertheless, about Carson, at Eagle and Honey Lakes, Cal., and at The Dalles, on the Columbia, their presence was detected, and is to be accounted for through the natural dispersion of the species. Elsewhere as at several localities near Camp Bidwell, Cal., the several covies are the descendants of birds brought from the Pacific slope and let loose to shift for themselves. They are nowhere in this region very numerous.

*Desription of first plumage of young.*—Prevailing color of the head, neck, back and breast grayish olive, more plumbeous beneath, and everywhere more or less sprinkled with white; the markings on the breast larger and of more regularly deltoid form; chin, whitish; throat and cheeks mixed with dark plumbeous, a dusky auricular patch with an indistinct whitish line just above. Crest, 1½ inches long; black, with tips irregularly marked with zigzag lines of pale fulvous. Scapulars, wing-coverts, tertials, and rectrices pale brownish, finely vermiculated with dusky. Abdomen whitish; flanks marked with chestnut and white; bill blackish; feet pale brown.

### LOPHORTYX Bonaparte.

*L. californicus* (Shaw). California Valley Quail.

This quail is nowhere indigenous along the eastern slope, as the high mountains offer a complete barrier to its extension. Those introduced about Carson appear to just hold their own.

## CHARADRIIDÆ—Plovers.

### ÆGIALITIS Boie.

*A. vociferus* (L.). Killdeer Plover.

An abundant summer inhabitant of this whole region, the mountains excepted. Nests on the marshy borders of all the lakes. Numerous fresh eggs were found at Washoe Lake, Nevada, May 30.

## RECURVIROSTRIDÆ—Stilts, Avocets.

### RECURVIROSTRA Linnæus.

*R. americana* (Gmel.). American Avocet.

Our knowledge of the range of this species over the United States is so full and complete that little remains to be added. Except immediately upon the Pacific coast, where it is found in comparatively small numbers, no portion of the Rocky Mountains and the region to the westward has been entered by our parties without finding this bird, at the proper season and in suitable localities, abundant.

During the migrations its distribution in the West is extremely general, and its presence is to be expected along all of the streams, ponds, and lakes, except, perhaps, in the highest mountainous districts, from the Mississippi to the Pacific.

In the breeding season its range is scarcely less restricted, and those sections only are exempt from its visits that lack the necessary requisites to its mode of life at this period.

In the neighborhood of Washoe Lake, Nevada, it is especially numerous, and here, about the middle of May, I found the birds paired, while some, at least, were building. They were first noticed on some small ponds near the shores of the lake, a locality quite typical of their choice at this season. The muddy flats of such little inlets always prove more attractive to birds of their habits than larger bodies of water, inasmuch as the shallows permit them to wade about with perfect freedom; while food, which in summer consists very largely of the larvæ of aquatic insects, is more abundant in these tepid waters, as well as more readily obtained. I have sometimes thought that *alkaline* marshes and ponds were really preferred by these birds, attributing this choice to the possible fact of the greater abundance of the larvæ alluded to in such. Be this as it may, the fact that water happens to be extremely brackish and alkaline is at least no drawback to the avocets.

While the avocets are waders in the fullest meaning of the term, they are also adept swimmers when choice or necessity calls; but of this accomplishment, so far as my observations go, they rarely when unmolested avail themselves. I remember on one occasion to have seen a wing-tipped avocet trust itself pluckily to the waters of a broad lake and swim steadily out, though in the face of a gale that I should have thought a duck could scarcely have stemmed; since which time I have always entertained a high opinion of the natatorial powers of this species, although, as remarked before, they are usually held in abeyance.

On the occasion of my first visit to the place mentioned above, I found the birds, with now and then a stilt, in considerable force, and so great was their solicitude at my intrusion and so vehement their outcries, that I took it for granted I was in immediate proximity to their nests. My search proving of no avail, I accepted without hesitancy the apparent fact that I had anticipated by a few days their nesting-time; and it was not until June 1 that I learned the full extent of the deception that the wily birds had practiced upon me.

While collecting at that date in a very similar locality half a mile or more up the lake, I found myself possessed of their secret, and in the midst of a large colony of both avocets and stilts, while numbers of the nests of either bird rewarded an easy search. As was plainly to be seen, it was their foraging trips that carried them away from home to the place where I had at first encountered them. Even at this remote point, their anxiety, real or pretended, had enabled them to effectually blind me as to the actual situation of their breeding-ground.

If the outcries of the few had been noticeable before, the confusion of sound resulting from the combined numbers of the whole colony was simply bewildering. The unfortunate pair whose nest I first stumbled upon used all the artifices common to birds in such a strait to entice me away. They would run furtively about a few yards distant, and then squat close down to the ground, and grovel in the loose earth as if settling over their eggs, while they kept uttering subdued coaxing notes as though calling to imaginary young. Their efforts at simulating the actions of wounded birds, which was the evident significance of the drooping wings and staggering gait adopted, were not very successful, and the nature of the deception was too apparent to deceive even a novice. After a while they appeared to become convinced of the futility of these attempts, and then rage took the place of sorrow. Flying about me in wide circles, the various pairs screamed and scolded till apparently exhausted by the excess of their emotions, when they betook themselves to a safe distance. I could not help fancying that the amount of sympathy extended the bereft birds by their neighbors was in pretty exact ratio to the proximity of their own nests, those pairs being the most ventures and vehement whose own danger appeared greatest, while away on the verge of the marsh stood quietly or fed leisurely about, in fancied security, those couples whose distant homes seemed not to be threatened.

In placing its nest the avocet shows a certain degree of cunning, and for this purpose usually avails itself of some little islet or isolated strip of marshy ground where its eggs and young are comparatively removed from the danger of intrusive visits from all four-footed prowlers. One enemy they have from which this situation offers no protection. I refer to the inland gull of this region, the *Larus californicus*. Gulls, as is well known, are very fond of eggs, and never allow a chance of robbing other birds to pass by unimproved. In the present instance the outcries of the abused avocets had attracted the attention of a flock of the above birds that had been hovering over the lake, and, apparently scenting their opportunity, they swept in on poised wings or moved in gentle circles, awaited a favorable moment to descend to the feast.

That both avocets and stilts were well aware of the proclivity of these new foes was soon apparent. For when one of the gulls, becoming, perhaps, impatient, flew in close to the nests, all the birds near, forgetting on the instant their human enemy, combined to repel this fresh assault. Gaining a vantage ground above the big birds, they pounced down, striking their foes with wings and bills, until the gulls were forced to a hasty and ignominious retreat. These attacks and counter-attacks were repeated several times, until the gulls, discomfited by their warm reception, left the vicinity.

The eggs are laid in plain view, and are quite unprotected by grasses or other screening. The slight hollow, scratched and patted down in the damp soil to receive them, is occasionally quite thoroughly lined, oftener very slightly, with bits of weeds, stalks, &c. The number of eggs varies from two to four.

### HIMANTOPUS Brisson.

*H. nigricollis* (Vieill.). Black-neck Stilt.

The mode of life of the stilt is, in all important particulars, like that of the avocet, and so invariably have the two birds been associated when under my notice, especially at the breeding period, that anything which brings to mind the one species is sure to recall the other. This companionship is a purely accidental one, arising from an independent choice of the same localities, under the promptings of similar tastes as to food and other necessities. Both are waders par excellence. But if the stilt ever swims at all, and it doubtless possesses this power to a certain extent in common, I believe, with each and every member of its long-legged fraternity, it must be only in extreme emergencies. I have myself never seen it take to the water under any circumstances. In many other minor particulars of habits and actions the two birds differ.

In the West one may expect to find the nests of the stilts alternating at short distances with those of the avocets, as if the two were unconscious or at least indifferent to each other's presence. Indeed, in many instances it would be no easy task to satisfactorily identify the eggs of the two species in the rabble of parent birds that hover around the intruder, were it not for the fact that the very considerable difference of size in the birds is exemplified in the eggs, those of the stilt being very perceptibly the smaller, corresponding with its more slender and everyway less bulky body.

When a colony of the two species is disturbed, they seem to vie with each other in the importunity of their attempts to mislead the intruder. Thus it often happens that the egg collector will find himself at his wit's end to determine the precise ownership of a clutch of eggs before him in the dozen or more stilts and avocets which are flying about. He has only to exercise a little patience and remain quiet until the excitement of the birds has had time to abate somewhat, when pair by pair the strangers will drop away till one or two only are left. From these he will soon be able to pick out the owners of the particular nest by their more persistent and manifestly greater solicitude.

The young of both species leave the nest almost immediately upon being hatched, and I have several times found them in a condition so weak and helpless that they seemed scarcely able to stand, much less walk; suggesting indeed, by their helplessness, the possibility of their having been removed from the nest by the parent birds upon the first sign of danger.

## PHALAROPODIDÆ, Phalaropes.

### STEGANOPUS Vieillot.

*S. wilsoni* (Sab.). Wilson's Phalarope.

Of the three species of phalaropes the present is much the best known, probably because of its very general diffusion throughout the interior, and because it breeds abundantly with us.

In the region in question it has been found to be plentiful, both as a spring and fall migrant and as a summer resident.

This phalarope was first noticed about Washoe Lake, Nevada, May 17, and the first arrivals from the south probably occur early in this month. By the 23d many had paired, and much anxiety was manifested when I approached certain localities in the marsh, where, however, I could find no nests. At this date they were probably just about ready to lay, and a female, when dissected, was found to contain a well-developed egg.

For nesting purposes this bird appears always to prefer the borders of little pools, and the grassy, boggy edges of prairie sloughs, to the neighborhood of large bodies of water; and in this region one rarely approaches a locality of the nature of those first mentioned without being met by one or more pairs of phalaropes, that come flying to meet the visitor with subdued and solicitous notes that clearly betray their anxiety to learn the character of his errand.

As their nests and eggs have often been described, they need not be touched upon here.

### LOBIPES Cuvier.

*L. hyperboreus* (L.). Northern Phalarope.

Of more common occurrence upon either coast, this phalarope is yet occasionally found in our interior during both the spring and fall migrations. Thus the last week of May the little ponds and inlets about Washoe Lake were found to contain numerous flocks, large and small, all which seemed to be in the greatest possible haste to reach points unknown farther to the north.

The little phalarope unites in itself the characteristics of several families, and seems, as it were, a sort of connecting link between them. Thus in it appear the general outlines and trimness of form that distinguish the sandpipers, joined to a plumage much like a duck's, while the lobing of the feet appears to be modeled after the plan of the coot's. Its habits express these peculiarities of structure very nicely, for in nimbleness it simulates the sandpipers, if, indeed, it does not surpass them; while very few of the latter can compare with the lobe-foot in grace and elegance. Added to these qualities, its natatorial powers, when are taken into account its diminutive size and pigmy strength, are really of first-class order.

It is difficult to imagine a more beautiful sight than that presented by a flock of these phalaropes as in their brightly-colored nuptial dress they pass with graceful action along the shallows in search of food. In some respects their movements when thus engaged are peculiar and quite unlike those of any other bird with which I am acquainted. The flocks I saw kept closely together, and in a compact body moved hastily along, each bird gleaning the ground as he advanced by a continuous movement from side to side, the body being turned quickly, as on a pivot, and the bill lowered into the water with a quick thrust. This action gave each bird the appearance of describing at every movement a full half circle, while the motions of the whole flock were so constant, rapid, and uniform that they resembled more the actions of a living machine moved by one impulse than a flock of individual birds actuated by separate wills. In the manner described they passed in a very few moments over considerable space, and I think it likely that these flocks were actually migrating at the time; at all events, the course maintained by them, as long as they were under notice, was a due northerly one.

Like most other species whose "make-up" enables them them to swim and wade with equal facility, our phalarope prefers the latter, and when feeding quietly only avails itself of swimming when it encounters some deep channel that interferes with progress. Or, again, when disturbed by too close scrutiny, they take to the water with an assurance that indicates it is no novelty to them. Thus they frequently became alarmed under my espionage and swam to the midst of the pond, and, having put between us what they considered a safe distance, gathered quietly in a compact circle and awaited further developments with an air of wonder and innocent expectation that was very amusing, as well, too, as touching in its utter unsophistication.

This species attains a nearly full development of the nuptial plumage within our limits, as was evidenced by the birds referred to here.

The females, as in case of the other two species, are much the brightest of the sexes, and the most highly colored male hardly equals the dullest female.

Upon dissection, evidence appeared of strong sexual excitement in both sexes, and I am inclined to believe that this phalarope will yet be found to breed along our northern frontier, possibly even in the mountains of Oregon. In fact, Dr. Cooper speaks of having seen a pair of either this species or the red phalarope in the Cascade Mountains of Washington Territory in August, which he thought were probably breeding. The latter species has never fallen under my observation in the West, and it is chiefly maritime.

## SCOLOPACIDÆ—Snipe.

### GALLINAGO Leach.

*G. wilsoni* (Temm.). Wilson's Snipe.

Although the range of the Wilson's snipe during the migrations covers the United States from ocean to ocean, its breeding limits are much more circumscribed, being chiefly along and beyond our northern borders. But in many of the mountainous sections of the far West it finds a climate and conditions well adapted to its needs, and here it passes the summer at a somewhat lower latitude than in the East. In Oregon, as also throughout all that portion of Eastern California and Western Nevada to the north of the line of the railroad, the Wilson's snipe may be confidently looked for in summer in all the little mountain meadows and along such alpine streams as by virtue of their overflow are bordered by the soft, oozy spots which are so indispensable to its habits. As often as otherwise these tracts occur among pine timber at quite elevated altitudes.

I first became aware of its presence in Nevada June 15. At this date, while making camp just at dusk near a small stream at the base of the mountains, I heard for the first time the peculiar sounds which are made by this snipe during the excitement of the love season, and I confess that at first I was not a little puzzled to explain their authorship. Afterwards I had several opportunities to observe the birds in the very act of producing them. The first impression received, shared in, too, by other members of the party as the sounds were borne to the ear from a distance, was that they were the notes of one of the small owls, muffled and disguised by reason of the remoteness of the bird. As the snipe flew nearer, and particularly as it passed directly overhead, the nature of the sound became more apparent, it then being comparable, as closely as anything I could think of, to the whistling noise which is so marked a peculiarity in the flight of the common dove (*Zenaidura*). This was the comparison that was suggested to all the party at the time, although it fails to give a very precise idea of its peculiar character. Mr. Ridgway hearing the snipe from a distance likens it to the "noise produced by water escaping from a nearly full jug," it having "a hollow, gurgling sound." However observers may differ in interpreting its peculiarities, no one, I think, who hears under favorable circumstances the sound we have attempted to describe, is likely to agree with Nuttall in his supposition that the sound proceeds from the bird's throat. It is unquestionably due to the wings alone.

The *modus operandi* is somewhat as follows: Mounting high in air the bird flies rapidly and excitedly back and forth, and at intervals of every moment or two, and while at full speed, the head is lowered, the wings bent and stiffened, and a downward plunge made at an abrupt angle, which terminates suddenly with a sharp ascent; and it is at the moment that the downward is changed to the upward flight that the sound is produced. To make such an extremely abrupt change in the line of flight possible, the wings must be bent into an unusual shape, and by reason of their action upon the air comes the whistling sound.

During the mating, and in fact through most of the breeding period, and continuing even after the young are hatched, the birds begin these evolutions as soon as dusk comes on, and continue them at irregular intervals until about nine o'clock. The notes are not heard again till about daybreak, and they cease before sun-up. But should the day be cloudy the snipe may be seen flying in the manner described till late in the morning, often indeed till nearly noon. I think that the males alone are concerned in the production of these odd notes; but of this I am not sure. The sexes have a harsh call-note in common which they utter as they fly casually about, which may be expressed by the syllables kâ-kâ-kâ-kâ; thus very different from the "musical" scaip-scaip, so familiar to every sportsman.

Other evidence is not wanting to show that our long-billed friend of skulking proclivities allows the events of the love season to quite turn his head, and various are the idiosyncrasies that take the place of his usual staid habits. One need not, then, be surprised upon putting him up in summer to find him alighting on a tree or fence-rail, and, so perched, to stand for long intervals as though rapt in deep meditation.

In the region in question the snipe apparently begins to nest some time in May, and by the middle of June I found young not fully divested of the down.

Several nests were found with the cracked egg-shells lying immediately about. They are usually built on a tussock of grass, if indeed the term building is applicable to the slight structure made by bending down a few grass blades and adding a few bits of withered herbage.

### TRINGA Linnæus.

*T. minutilla* Vieill. Least Sandpiper.

Common during the migrations.

### EREUNETES Illiger.

*E. pusillus* (L.). Semipalmated Sandpiper.

As preceding.

### TOTANUS Bechstein.

*T. semipalmatus* (Gmel.). Willet.

Present about Washoe Lake in May, where it probably breeds, as it certainly does in many similar localities to the northward.

*T. melanoleucus* (Gmel.). Greater Yellow Legs.

Numerous as a migrant. Flocks of this species were seen on their way south as early as July 27.

### TRINGOIDES Bonaparte.

*T. macularius* (L.). Spotted Sandpiper.

A summer visitant throughout this region, although not very numerous.

### NUMENIUS Linnæus.

*N. longirostris* (Wils.). Long-billed Curlew.

Numerous as a summer resident along the marshy borders of the large lakes, but most abundant during the fall migrations. In August the stubble-fields near Goose Lake were fairly dotted with these birds, busily at work hunting grasshoppers.

## TANTALIDÆ—Ibises.

### PLEGADIS Kaup.

*P. guaranna* (L.). Bronzed Ibis.

This ibis has an extensive range in the west, it finding place as occurring at one season or another in nearly all the local lists of the country west of the Mississippi River. It reaches to the north as far as Southern Oregon, where it breeds. As the species was not found by Bendire about Camp Harney we may perhaps assume that the above is about its northern limit. Nowhere is it more abundant than in the region from the line of the railroad to Northern California and Nevada, being there found in summer as an inhabitant of the tulle swamps on all the lakes large and small, except in the high mountains.

Its general habits are much like those of the herons, and the marsh and slough are not more essential to the mode of life of the latter birds than of the glossy ibis. During the migrations, it is true, flocks of ibises may be seen feeding in plain view in the open shallows along shore, but it is quite exceptional to find them in such situations during the breeding season. Apart from their habit of nesting among the rushes they seem to prefer the secrecy and solitude conferred on them by the sheltering reeds, and if the marsh be treacherous and oozy so much the better is it likely to prove for their special purposes as favoring complete isolation. While duck-shooting the report of my gun has frequently started up a dozen or more of these ibises, that sprung with hoarse croakings from little muddy pools and recesses almost within stone's-throw, where, screened upon all sides, they had been quietly feeding without conveying a hint of their presence.

Inherent in the nature of the ibis there is a certain wariness which to some extent makes amends for its natural stupidity. For, to few birds does the term stupid apply with more force than to the present species. The very "make-up" of the bird is suggestive of a sluggish disposition, there being evident a certain ungainliness of form that it is impossible to associate with keen intellectual activity, and that is the very reverse of what is implied by the alert actions and elegant appearance of its allies, the herons. Doubtless the long, heavy bill and slender neck surmounting its thickset body contribute much to its uncouth appearance, and convey an impression which the really beautiful plumage serves only partially to dispel. However, the ibis may safely claim that, even if its appearance is not in all respects pleasing to the eye, its ensemble has at least the beauty of utility, and its stout legs and long toes and claws, its heavy, curved bill and long neck all serve most admirably the purpose intended, which is, after all, the chief consideration.

By the 20th of May the ibises all appeared to be paired about Washoe Lake, although neither then nor a week later was I able to find their nests. Perhaps this was a little early for the deposition of the eggs, although the oviduct of a female shot June 3 contained a perfect egg.

## ARDEIDÆ—Herons.

### ARDEA Linnæus.

*A. herodias* L. Great Blue Heron.

A common summer inhabitant of this whole region.

### HERODIAS Boie.

*H. egretta* (Gm.). Great White Egret.

Colonies of this species reside in summer on many of the lakes which lie at the foot of the mountains in Eastern California and Western Nevada, while we learn from Captain Bendire of an extensive heronry as high to the north as Lake Malheur, Oregon.

Warner Lake, just within the southern borders of that Territory, forms a favorite resort for several species of the heron family. The white egret unites with the others to form colonies that build their nests in the larger growth of willows along shore.

Visiting such a heronry in September I found a dozen or more of the partially fledged young swinging by the necks from the crooked branches where they had evidently fallen as they clambered about the nests, and perishing miserably had hung till converted into mummies by the dry winds.

### GARZETTA Kaup.

*G. candidissima* (Jacquin.). Little White Egret.

Observed at several localities in Nevada and Eastern California where it is not so common as the preceding.

### NYCTIARDEA Swainson.

*N. grisea nævia* (Bodd.). Night Heron.

Perhaps the most abundant of the family, and present in all the marshes.

### BOTAURUS Stephens.

*B. minor* (Gm.). Bittern.

A common summer visitant as far north as Southern Oregon, reaching perhaps into Washington Territory as it does to Puget Sound on the coast. (Cooper.)

## GRUIDÆ—Cranes.

### GRUS Linnæus.

*G. canadensis* (L.). Sandhill Crane.

These large birds are numerous in so many portions of Nevada, California, and Oregon that it is scarcely worth while to particularize localities.

They breed in many of the sub-alpine valleys, where are found meadows of sufficient extent to afford both food and protection, and to these and the tule swamps they mainly limit themselves and the young till the latter are able to shift for themselves. In some localities where such resorts are not available, an occasional pair of old birds may be seen accompanied by a young one or two feeding on the grassy plain or open stretches of valley, where plenty of food is found in the shape of grasshoppers. Let once an Indian catch sight of one of these families and he makes short work of the young birds, which are readily secured from horseback, or even run down afoot.

Towards fall the cranes become more numerous, or, at least, more conspicuous, and in the region mentioned form a part of everyday scene, as in small companies they feed about in open view or fly in long lines from one valley to another, uttering their indescribably odd notes.

I know of no other bird that carries its instinct of caution to so great an extent as does the crane; and he must be careful indeed or greatly favored by fortune who obtains a shot at one.

The crane is usually held to be delectable fare; but my own experiments upon them, as served up in camp style, have not been entirely satisfactory, and I have found them tough and somewhat too gamey to bear the test of even a mountain appetite.

## RALLIDÆ—Rails.

### PORZANA Vieillot.

*P. carolina*, Cab. Carolina Rail.

Found throughout the summer, but apparently not so common as the succeeding species.

### RALLUS Linnæus.

*R. virginianus* (L.). Virginia Rail.

Numerous about all the marshy lakes.

### FULICA Linnæus.

*F. americana* (Gm.). Coot.

An extremely abundant summer resident of all the lakes, large and small, of this region.

They begin to build, about Washoe Lake, Nevada, the middle of May, at which date but few eggs had been laid, the majority of the pairs being still engaged upon their nests.

Their nests and nesting habits are too well known to need description here. A clutch consists of from seven to twelve eggs. The latter number, however, is very exceptional, nine being perhaps the average nestfull.

## ANATIDÆ—Ducks, Geese.

### CYGNUS Linnæus.

*C. americanus*, Sharpless. Whistling Swan.

The swans are among the latest migrants from the north, and hence come too late to fall under observation of our field parties.

With the approach of cold weather they occur in most or all the large lakes of this region, as well also upon many of the large streams.

It is certain that the above species occurs as stated, and, in all likelihood, the *C. buccinator* is also found at the same time.

### ANSER Linnæus.

*A. gambeli* (Hartl.). Speckle-bellied Goose.

Towards the last of August in Northern California this species began to arrive from the north in considerable numbers. It becomes very abundant at a somewhat later date.

*A. hyperboreus*, Pall. Snow Goose.

Arrives rather later than the preceding, and perhaps in rather fewer numbers.

The Chen (*Chen Rossi*) has been found by Captain Bendire at Malheur Lake, Oregon, and in all probability is of regular occurrence as a migrant on the interior chain of lakes. The past winter (1878-'79) it has been exceptionally numerous in the Sacramento Valley and along the coast.

### BRANTA Scopoli.

*B. canadensis* (L.). Canada Goose.

The extensive lakes of Western Nevada, Eastern California, and Oregon, afford summer haunts for many of the Canada geese, or honkers, as they are popularly called, to distinguish them from the smaller Hutchins' goose and the "speckle bellies," neither of which birds remain in summer within our boundaries.

The nesting season of the Canada goose is well nigh over ere others of the feathered tribe, save perhaps some of the *Raptores*, are thinking of beginning, and the deposition of the eggs takes place in this region as early as February. Their mode of nesting is various. At Pyramid Lake the islands are extremely rocky, and here the geese build either under bushes along shore or resort to spaces underneath overhanging cliffs, or even to hollows in the rocks that form slight caves. Another and perhaps the most usual location for the nest is on the sandy spits of islands. The wariness which characterizes this goose, as to a less extent the other members of the family, undergoes no relaxation at this season, but, if anything, is increased. The spot selected to receive the eggs must be secure from all chance of intrusion—hence their partiality for islands; and as soon as the young are able to take to the water they are guided to some safe feeding ground, usually in the shallow water along some solitary shore. This care is rendered the more necessary, inasmuch as a long period must elapse for the young to receive their full powers, and they obtain nearly the size of the old birds ere their pinions are sufficiently developed to raise them from the water. Not infrequently, when riding along the rarely-visited shores of the lakes in the remoter districts, our parties have come suddenly upon these families of half-grown goslings, but rarely indeed ere the watchful parent had caught the alarm and had urged her convoy to a safe distance from the shore. Their food is now obtained wholly from the water, and not until the young have passed quite out of the gosling stage and have become fully developed in every respect do old and young assemble into flocks or "gaggles," and their visits to the stubble fields and pastures begin.

The birds that breed in this region start southward at a period nearly coincident with or a little before the arrival of the full flocks from more northern grounds. Just prior to setting out they are in the best condition, being fat and juicy from their mingled fare of grain and tender grass shoots.

### ANAS Linnæus.

*A. boschas* (L.). Mallard.

One of the best known, as also one of the most highly esteemed, of all our ducks, its extensive range and great abundance wherever found, entitles the mallard to a place in the front rank of our valuable food-birds. In the West, as a table bird, it takes precedence, I think, of all others, its very general habit there of feeding upon grain for a part of the year conducing to its excellence of flavor.

In the region our report covers it is very numerous, not only during the migrations, but also in summer, when large numbers remain to breed about the various lakes. For this purpose it resorts to precisely the same localities as the red-breasted teal, viz, the partially submerged marshes; although, in truth, but little change of locality is in case of either of these birds necessary, since their tastes lead to the choice of similar places all the year round. So much alike, in fact, are their habits of nidification that during a day's hunt I have found many nests of the mallard alternating with those of the teal, and in many instances the nests of the two were but a few feet apart.

The mallard begins to lay during the last days of April and the early part of May, and by the 23d of the latter month I found several nests in which the eggs were far advanced, while in one the ducklings had appeared.

The mallards place their nests much as do the teals, but are, perhaps, more inclined to seek out standing tufts of dried rushes, doubtless because in them they can more readily conceal their bulkier bodies; at the base of these they have no difficulty in forming a safe and commodious retreat. At first, and in the majority of cases, little attention is paid to the nest proper, and a slight collection of dried rushes and grass, sufficiently hollowed to contain the eggs and the body of the bird, is all that is required. The lining of soft down, plucked from the breast and belly of the devoted female, is deferred till later, it rarely being found till the complement is nearly completed, and it more frequently still being left until the eggs have been incubated for a considerable period.

I have never found more than ten eggs in a nest, though I have seen broods of eleven under convoy of the parents, and perhaps the full dozen are sometimes laid.

When disturbed the mallard rises heavily from its nest, its fright occasionally compelling a volley of loud quacks, while at other times it flies away in perfect silence. In case of the female, she may then show her concern by flying in wide circles near the nest; and this she is especially likely to do when the maternal instinct has become strong by long brooding. But should the nest contain only a few newly-laid eggs, much less apprehension is displayed, and then she flies straight away to remain in hiding for some hours, or until completely reassured. Often, under the latter circumstances, the nest is never reoccupied, but a second begun after a delay of twenty-four hours or so.

Soon after being hatched, the downy young are led by their parents, not into open water, where would follow a well-understood danger from hawks and other enemies, but into the shallow inlets, where they can be screened by the heavy covert of reeds; and they are not allowed to venture out of these until able to shift for themselves. I think that for the first few nights after being hatched the tender young are led back and brooded in the nest. But the interval during which the young are most exposed to danger is in the "flapper" state, or when they have attained considerable size, but have not yet received the power of flight, for the rectrices, as is well known, are the last feathers to be developed. They now flap along the surface of the water in a curious sort of way, half flying, half swimming, and when cornered in shallow water, as may often be done, they fall easy prey. This is the accepted time of feasting for numerous species of hawks, not to mention such formidable four-footed enemies as coyotes, foxes, etc., while most to be feared of all is its human foe in the shape of the Indian. Armed with clubs, the boys and squaws enter the shallows, and by beating the reeds drive the young before them till they are congregated in some favorable spot, when they are slaughtered by the scores. I have seen Indians returning from one of these ducking expeditions fairly loaded down with spoil, the young ducks hanging by the necks in festoons, and almost hiding by their numbers the dusky bodies of their slaughterers. Ducks' eggs and ducklings form in fact during summer no small part of the Indians' fare.

Probably none of the mallards raised in this region pass the winter here, but migrate south, and are replaced by more northern-born birds, so that about the numerous warm springs and ponds of open water the mallards are to be found throughout cold weather, until spring once more impels them northward.

### DAFILA Leach.

*D. acuta* (L.). Pin Tail.

Abundant during the migrations; one breed.

### CHAULELASMUS Gray.

*C. streperus* (L.). Gadwall.

This fine duck breeds abundantly throughout this region.

### MARECA Stephens.

*M. americana* (Gm.). American Widgeon.

Breeds more or less commonly in this region; most abundant as a migrant.

### QUERQUEDULA Stephens.

*Q. carolinensis* (Gm.). Green-wing Teal.

Scattered pairs of this teal breed over all this region, and in some localities it is doubtless numerous.

While crossing the desert north of Reno, early in July, we found in the solitary pool of water, which with its scanty growth of green rushes forms the only oasis for miles around, a family of this teal consisting of a female and ten young. The pool being of too small extent to furnish shelter in such danger, the mother bird led the band to the shore and directly into the sage-brush, into which they dived and hid as though fully alive to the emergency of the case.

This teal is most abundant as a spring and fall migrant, its proclivities hence being for more northern summer grounds.

*Q. discors* (L.). Blue-winged Teal.

This species was not seen at all during the summer; nor, as a migrant, does it appear to be as numerous in this region as either of its congeners.

*Q. cyanoptera* (V.). Cinnamon Teal.

This teal is one of the few ducks whose range is so far circumscribed that it may be spoken of in general terms as a western species, the area occupied by it, even during the migratory seasons, not extending to the east of the Rocky Mountains, except in

Texas. Although noted from Louisiana, its occurrence there is presumed to be quite accidental. It furthermore appears as a summer resident in almost every section where it is known at all. It breeds about the Columbia River, at present its northernmost recorded limit. Southern Colorado, on the other hand, as determined by our parties, is included in its summer range, as possibly also Arizona and New Mexico, although of the latter fact no absolute proof was obtained. In many localities in the intermediate regions it is one of the most abundant of summer visitants, and in no place more so, according to my knowledge, than in Western Nevada and the contiguous regions.

It makes its appearance on the lakes of Nevada early in the spring, at a date nearly coinciding with the general impetus northward to be observed in the ducks and water birds generally. At the time of my first visit to Washoe Lake, May 12, all of the teal appeared to be paired, while not a few had so far progressed in their housekeeping matters as to already have eggs.

With all the ducks there is noticeable a great variation in the time of nesting, even at the very same locality. The cinnamon teal forms no exception to this rule, and from the above date onwards I found nests in all the various stages of advancement. Fresh eggs were found as late as the 1st of June, although most of the nests at this date contained either young or eggs very far advanced. Perhaps a certain proportion of the late breeders are to be accounted for on the supposition of the destruction of the first nests, for ducks have many enemies at this season; and fresh duck-eggs as well as young birds have an especial attraction for all the smaller carnivores.

The teals' nests will be found scattered over a marsh at large, their chief care being to secure a dry spot out of reach of the danger of inundation, which is their principal risk, and the cause at times of the destruction of great numbers of the eggs. Some seasons of high water about Washoe Lake, as I was told by the ranchmen, prove most ruinous to the first clutches, and the swollen inlets of the marsh have been observed at such times to be fairly dotted with eggs of the various kinds of ducks, which had been floated off by the rising waters.

An apparently secure locality found, a pair soon satisfy themselves with some special little nook. They never, I think, build in the heavy beds of tule, but either select an isolated bunch of rushes, or else place the nest in the midst of the short waving marsh-grass, where it is sufficiently thick to protect the setting bird from ordinary observation. Occasionally, too, they nest upon the dry land under a bush, and more or less distant from water. But in any event the nest must be within easy reach of a good feeding ground, and is usually not many yards, perhaps but few feet, distant from some pool or stream. Ducks have plenty of opportunity for the exercise of cunning in their domestic arrangements, and some of the pairs display infinite address in hiding their nests, and the eyes of the most observant collector, be he two or four footed, will often in vain scrutinize the very clump of grass wherein is hid the mother bird nestling close down to her treasures, secure, till a blundering step starts her from her charge. If a clump of rushes be selected as a nesting site, the bird enters from the side through a space so small that, once inside, it needs but a few slight touches of the bill to replace the stalks disturbed by her entrance, and restore everything to its natural appearance. And this the female is knowing enough to do, as she is also to carefully cover the eggs during her temporary absences. Like the mallard, and probably most if not all other ducks, the cinnamon teal is very indifferent as to the state of the nest at the time the first eggs are laid, and leaves the final touches till towards the period when the young are about to appear. Then, to provide a soft bed for her offspring, the female quite denudes the under portions of her body of its downy feathering, and with the material obtained in this way warmly felts the nest.

The teal is a close setter, and the female will occasionally prove so devoted to her charge as to permit herself to be caught by hand. If the young be out, there is scarcely any limit to the hardihood she will show in her attempts to distract attention from them. She flutters along the ground just beyond reach of the outstretched hand, and resorts to every effort of dissimulation likely to induce pursuit. I have seen the wounded, broken-winged bird, in particular, imitated so cleverly by this teal, that it was difficult indeed to persuade myself that it was a cheat.

The extreme number of eggs at a hatching is, I believe, twelve; and in some thirty nests examined at Washoe Lake this number was found only twice; nine, ten, and eleven being the more common complements.

In fair seasons the greater number appear to be hatched out, as I never saw a small brood; and occasionally every egg proves fertile. That this should be the case seems a little remarkable, when is considered the irregularity which marks the intervals of deposition.

When newly laid the eggs are of a beautiful, soft, creamy white, and the texture of the shell is delicate and a trifle rough under touch. Very soon after the full complement appears the shell becomes smooth and shining from the constant contact and rubbing of the bird's body, and the delicate texture is lost entirely. The color is also correspondingly changed, and now appears as a light buff, which darkens and stains as time goes on. Such are the usual museum specimens. Their exact shape is somewhat indeterminate, since, in the sets before me, many approach the true ellipsoidal, while others are simply oval in varying degree; some are elongated and quite pointed at the smaller ends; others are blunt. It is to be remarked that the peculiarities of size and shape are apt to obtain with but slight variations throughout the whole of a set. The two smallest eggs before me measure 1.88 × 1.27, and 1.82 × 1.32; and from this extreme they run up to 2.10 × 1.37.

The cinnamon teal is, in the interior, one of the very first of the ducks to start in fall on the southward migration, and, in the neighborhood of Washoe Lake, nearly all have left by the first of September; while those that breed farther north are not long in following. In California it remains later, and I understand from my friend, Mr. H. G. Parker, that more or less winter in the Sacramento Valley.

### SPATULA Boie.

*S. clypeata* (L.). Shoveller.

This duck is abundant in fall and spring in nearly all portions of the West. Nevertheless if it remains to breed, it does so apparently only in rare instances, except along our northern border, as in Dakota, where the young were found by Dr. Coues in August.

It is true that I detected the species at Washoe Lake in June. But upon killing a male the cause of its stay so far south was revealed in the shape of an old wound; probably, too, a greater or less number of barren birds are scattered over the lakes of this region.

### FULIGULA Stephens.

*F. marila* (L.). Greater Blackhead.

Numerous only as a migrant and winter visitant.

*F. affinis* Eyton. Lesser Blackhead.

Occurs as the preceding.

*F. collaris* (Donov.). Ring-neck Duck.

In noticing this species on previous occasions, especially in the report for 1876[1] I have given it as breeding in Utah, Nevada, &c. I was led into what I now am convinced was a mistake by the incorrect identification of several young birds. These I now ascertain to have been the young of the redhead (*F. americana*), as similar specimens taken the past season of unquestionable identity show. I take this occasion therefore to make the correction, and all such references are to be understood as applying to the redhead, and to it alone. We have no proof at the present, so far as I am aware, that the ring-neck breeds within our limits, and it doubtless retires in summer to points far beyond our boundaries. During both spring and fall it occurs in greater or less numbers according to locality.

*F. ferina americana* (Eyton). Redhead.

Better known, perhaps, as a bird of the east coast, the redhead is yet a well-represented species on the west coast, and also to a somewhat less extent of the western interior. It was found breeding, though not in great numbers, about Washoe and other lakes in Western Nevada and the contiguous portions of California. This is, I believe, a summer range much farther south than is usually understood to apply to this species; although young birds taken at Rush Lake, Southern Utah, by myself, affords good evidence of its summer residence at that point.

Its method of nidification is in general much like the other species. One nest found by Mr. H. G. Parker was somewhat singularly placed, in that it was built in perfectly bare, open ground. A hoof-track in the mud, which had subsequently been left high and dry by the receding waters, received the nest, composed in this instance entirely of feathers and down, there being, in fact, no room in the narrow quarters for other accumulations. A second was built close to the water's edge under protection of a little clump of grease-wood bushes. The eggs numbered in these instances respectively five and seven, incubation in neither having begun.

I append the measurements of three of the first set, merely remarking that, except for their more spherical form and perhaps rather larger size, they would be indistinguishable from the mallard's: 2.23 × 1.73, 2.21 × 1.73, 2.17 × 1.70.

### BUCEPHALA Baird.

*B. clangula* (L.). Common Golden Eye.

An abundant migrant.

*B. albeola* (L.). Buffle-head Duck.

As preceding species.

## PELECANIDÆ—Pelicans.

### PELECANUS Linnæus.

*P. erythorynchus* Lath. White Pelican.

The white pelican is less known from its occurrence on either coast than from the abundant numbers that inhabit the great interior lakes. From their great extent, and in many instances complete isolation, as well as their containing an abundance of fish, the lakes of Nevada, California, and Oregon are especially favored by this bird, and on certain of them, as Pyramid, Eagle, and Goose Lakes, the pelicans are found in summer in immense numbers.

So much has been written from time to time upon the breeding habits of this species, that most persons interested in the subject may be presumed to be pretty familiar with them, and this part of the bird's biography need not be enlarged upon here to any extent.

Naturally the white pelican seems to be rather stupid, and, when the privacy of a breeding colony is encroached upon for the first time by a human being, the liveliest feeling his presence is apt to excite is intense curiosity, which is occasionally carried to such an extent that the birds appear as though too completely overwhelmed with astonishment to take any special precaution for their own safety. Under such circumstances they may occasionally be so closely approached as to be killed with clubs. No creature however so dull as not to profit by the lessons that experience teaches, and the treatment the pelican usually receives at the hands of man is of such kind that in him they soon learn to recognize an enemy to be feared and shunned on all occasions. Such is the case at Great Salt Lake where the former great abundance of the pelican is attested by all the early explorers, but where now the bird is known only as a casual visitant. Persecution is having a similar result at Pyramid Lake, Nevada, where a few years ago the birds were so tame as to permit themselves to be almost caught by hand. At present, though still abundant, they are excessively shy having been driven entirely away from certain of the islands by treatment which must eventually cause their complete disappearance.

From its large size and conspicuous plumage, and the habit of colonization at the nesting period, added to the complete exposure of the eggs upon the sands, and finally from the fact that the young when hatched are perfectly helpless for a period of over a month, the pelican is peculiarly exposed to the assault of its enemies. From four-footed foes it secures immunity by nesting upon islands, a precaution which, of course, proves of no avail from its human persecutors.

At Pyramid Lake a crusade has been inaugurated against the pelicans by the fisherman, whose cause is justified in their own eyes by the voracity of the big birds, and the number of fish consumed by them. In a single day, as I was informed, over 700 eggs belonging to one colony were destroyed. This complaint of injury done the fishing interests is not, it must be said, without some foundation. The number of pounds of fish consumed in a day by the combined numbers of a large colony of pelicans, especially when feeding young, must amount to something fabulous. As a rule, however, and from the nature of the mode of fishing practiced by the white pelican, fish of value, as the trout, are but little exposed to their attacks; the species they are able to obtain consists chiefly of the smaller fry found in shallow water, and of little or no table-value whatever, their principal, if not their only, importance being as food for better kinds. As this small fry fairly swarms in all the western lakes, there is no danger at present, at least, that the fishing interests will be injured in this indirect manner, as indeed is plainly evidenced at Pyramid Lake, where, despite the number of the pelicans, trout exist in enormous numbers.

The method of obtaining their prey by banding together, driving the fish before them into shallow water and then scooping them up with open bill by means of quick rushes, I have often witnessed and is well known. The large size of the fish a pelican, under emergency, is able to dispose of, is somewhat surprising. I once saw a bird which had been wounded, and which was apparently unable to clear the surface of the water, throw up a sucker which I estimated to weigh not less than three pounds. Having rid itself of extra ballast to this extent, it flew away with ease.

The deposition of the pelicans' eggs takes place at a very early date; the colony at Pyramid Lake, as I learned, having laid many eggs by April 10, and this is I think about the usual date. As might be presumed, all the pairs of a colony do not begin laying at the same time; in fact there is much irregularity in this respect, and as a consequence there results a corresponding difference in the time of appearance of the young. This was clearly shown in the case of a community of from 500 to 1,000 pairs that had established themselves on a sandy island in Eagle Lake (Cal.), and which I visited July 4. At this date the young were present in all stages of growth, from the chick just breaking the shell to the youngster fully grown, but still unable to fly. A rough estimate placed this number at considerably over 1,000, and a more incongruous assemblage was never witnessed. As our boat approached the island the parent birds began to manifest some uneasiness, and when we were about two gunshots away they rose *en masse* and settled in the water at convenient distance for watching our proceedings. The younglings were considerably flustered when they found such strange creatures among them, and treated all our advances with marked disapproval. Forming into solid phalanxes of all sizes, they shuffled over the sands, the ranks opening to right and left with all alacrity according as we directed our steps. The appearance they cut as they waddled about on their unsteady legs, some of them almost naked and all ugly and uncouth, was ludicrous in the extreme. Even the older ones made no attempt at aggressive resistance when captured, but were content to show their repugnance at being handled by violent efforts to escape from our hands. Finally, in response to the coaxing of a few old birds that ventured in, many took to the water, and, having swam out three or four hundred yards, remained quietly eyeing our movements with all unconcern. Many gulls and several pairs of cormorants and great blue herons shared the island with the pelicans, and their young afforded living proofs of the unruffled tempers and good dispositions of the big birds.

At this lake the pelicans presented a peculiarly noteworthy sight as at intervals during the day they spread their broad wings and flew in bands of from five to fifty to the neighborhood of some one of the lofty peaks within a mile or two, where they amused themselves by sailing about for an hour at a time in the invigorating air and in encompassing the summits in wide circles. Their snowy-white plumage reflected the bright sunlight, and the huge birds appeared at their best as they soared above cañon and forest at such height that all ungainliness of form was lost and we were left to admire the snowy purity of their colors and their fine powers of flight.

The "centre-board," so called, a horny excrescence appearing on the bills of the adults about the mating period is, as has been shown by Captain Bendire, common to both sexes. This is shed as the season progresses, till, in early July, when the young are usually well advanced, it is rarely seen, although a few still persist at this time. Of its use nothing appears to be known.

## GRACULIDÆ—Cormorants.

### GRACULUS Linnæus.

*G. dilophus* (Sw.). Double-crested Cormorant.

The cormorants from this region have usually been referred to the variety *floridanus*, a name bestowed upon what was supposed to be a small southern race of *dilophus*. But my pair of specimens taken at Pyramid Lake, Nevada, in summer, are fully up to the requirements of size of *dilophus*, and I therefore so consider them. It is to be remarked, however, as has been indicated by Mr. Ridgway, that specimens occur in the region under notice, and in California, that are no larger than many Florida born birds. After examination of the Smithsonian material I am of the opinion that the alleged difference of size is of too doubtful applicability to warrant the recognition of this variety.

The double-crested cormorant is more or less numerous on many of the lakes of this region, its abundance at any given locality being chiefly regulated by the presence and character of nesting facilities.

All the nests examined by me were built in depressions and cavities on rocky islands, although in this same region they build upon trees, as fully attested by Mr. Ridgway. The nests were composed chiefly of sticks with a substantial lining of weeds. One was noticed that had an additional slight felting of feathers. No birds could well be less fastidious in regard to their nesting arrangements than they, and the foul odor about a cormorant rookery is almost unendurable. Entangled in one nest that I examined was the mummied head and neck of a brother cormorant that apparently had been gathered as available nest material.

Although the flight of the cormorant appears heavy and somewhat laborious, it yet progresses from feeding ground to feeding ground with tolerable ease and much swiftness. But the bird appears at its best in the water, where it is scarcely less at home than the typical divers, and where no little of its existence is passed beneath the surface in pursuit of its finny prey. This the cormorant never plunges for, but, like the grebes, divers, and other birds of that class, the best swimmers of all, captures it in full chase. The bird's forays are usually made into large schools, and apparently it has very little trouble in procuring all it requires. The cormorant is not always successful in holding a fish after it has fairly seized it, and at Eagle Lake there were to be seen in every school of white-fish (*Coregonus williamsoni*) a considerable number that bore across their bodies the marks of the powerful mandibles. I found quite a number of sizable fish that had escaped from the birds' bills, only to die a lingering death from the effects of compression.

## LARIDÆ—Gulls, Terns.

### LARUS Linnæus.

*L. californicus Lawr.* California Gull.

The present species is to be distinguished from the *L. delawarensis*, which it somewhat closely resembles, by the following characters:

*L. californicus*, adult—size larger; bill stouter; (wing, 15.43; tail, 6.24; bill, 1.82; depth above notch, .60; tarsus, 2.23).*

Mantle dark pearl blue, much darker than in the succeeding. Color of bill (in fresh specimens, sometimes retained in skins) bright yellow, *with an irregularly shaped spot of intense carmine near tip of lower mandible;* a spot or bar of black anterior to this on both mandibles. Iris hazel or brown; tarsi and feet pale green.

*L. delawarensis*, adult—size smaller; bill less robust; (wing, 14.49; tail, 6.06; bill, 1.45; depth above nostril, .51; tarsus, 2.07).†

Mantle pearl blue, always lighter than in preceding. Bill greenish yellow, encircled near tip by a broad black band. Iris light yellow; tarsi and feet naples yellow.

The amount of black on the bill of *californicus* is variable. Usually it takes the form of spots or bars, as given above, but such is by no means always the case. Not rarely, as in several adult specimens before me, it appears in the form of a complete circle as in *delawarensis*. In such cases, however, the ring is much narrower than in that bird. More rarely the black is almost or quite obsolete. Similarly, or even more variable, is the amount of white at tip of first primary. In a majority, perhaps, of specimens this is found as a terminal patch of about two inches in extent. Some individuals, however, apparently perfectly adult, have the tip and shaft black for three-fourths of an inch, the white being restricted to a spot on either web above the black area, almost precisely as in *delawarensis*. Others, again, may have the extreme tip white, above which is a band of black including both webs and the shaft, and giving way, higher up, to a second white area which may or may not include the shaft; sometimes, indeed, the shaft is black above and white below. Hence the spotting of the primaries and the black markings of the bill, points upon which considerable stress has been laid by some authors, are too inconstant to prove reliable guides in diagnosis, although not entirely without value.

In fall the adults of either species have the white of head more or less spotted or streaked with dusky. The carmine spot on the bill of *californicus* fades away, as also the crimson of eyelids and at angle of mouth, which is common to both species. The differences in size, especially of bills, and the color of the mantles may now be relied upon to separate them. To distinguish young birds, which always exhibit so much individual variation, becomes much more difficult, and I have found the size of bill to be the best and most constant feature.

The Californian gull is found as a very abundant summer resident throughout the entire chain of lakes, and is, so far as I can learn, the only representative of the family present here at this season. Upon stretches of sand, jutting out from the little islands in mid-lake, or occasionally among the rocks along shore, this gull constructs its nest, and deposits from two to four eggs about the middle of May. The nest is a somewhat rude and bulky structure, particularly if it chances to be placed in rocky interstices, and is composed of weeds, sticks, and similar coarse material gathered from the shores, and lined more or less substantially with finer gleanings.

The colonies are, as a rule, very large, one that I visited on Pyramid Lake containing several hundred pairs, and the nests occupy every available spot on the sands. Unfortunately for the gulls, the eggs are rich and sufficiently well flavored to be a welcome addition to the meager fare of the settler, and hence, when accessible, are eagerly sought for. The colony alluded to above had been visited every few days for a period of more than three weeks, and every nest rifled. But so tenaciously do the birds cling to a spot that has once been chosen as a nesting ground that many still continued to deposit eggs, sometimes in newly-constructed nests, but often in the plundered ones. Many of the females had laid so often that the coloring pigment had been exhausted, and, as a consequence, a considerable portion of the later eggs were almost unspotted. The eggs of this gull are so nearly like those of the ring-bill as to be practically indistinguishable, although they average a trifle larger. In the exact style and amount of markings they vary interminably.

*L. delawarensis* (Ord.). Ring-bill Gull.

Given by Captain Bendire as a "common summer resident" of Malheur Lake, Oreg. It is possible that a mistake has been made here, and that the statement really applies only to the *L. californicus*. If correct it furnishes us with the only instance of the bird breeding within the United States. Upon all the other lakes in California and Nevada that I have visited the ring-bill appears to be only a fall and winter resident, and as such is numerous.

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* Average of four specimens.

† Average of eight specimens.

### STERNA Linnæus.

*S. forsteri* (Nutt.). Forster's Tern.

Dr. Coues appears to have received an entirely erroneous impression in regard to the breeding range of this species, and assigns the interior of British America as its summer home, implying in his article in Birds of the Northwest its entire absence from the United States at this season, although he intimates a possibility of its being yet found to nest on or along the northern tier of States. The truth is this tern is an extremely abundant summer resident of Washoe and other similar lakes of Nevada and California east of the mountains upon which are found any considerable extent of tule or other marsh. It also occurs abundantly in summer in the great fresh-water marshes in the vicinity of Chicago, and also in Wisconsin. Upon the eastern coast its summer range is somewhat erratic, as it appears to be wanting along the New England coast, but is found at this season, in great numbers, on certain of the islands off the shore of Virginia and to the southward. Its absence farther north is, perhaps, to be accounted for from the lack of suitable localities, since the Forster's is as much of a marsh-loving species as the black tern, in contradistinction to the Wilson's, arctic, and others, which habitually frequent the open water, or, at least, avoid more the sedgy marshes.

Upon the western lakes the Forster's and black terns mingle fraternally together as they conduct their search for food over the broad expanse of oozy marsh or along the shallow, reedy shores. Moreover, the Forster's tern, instead of building on the open sands, has recourse to the marshes, thus still further following the habit of the black tern.

The single nest found by me consisted of a few bits of *débris*, and was placed on a muddy bank by the side of a ditch of running water.

### HYDROCHELIDON Boie.

*H. fissipes* (L.). Black Tern.

This species, which is a well-known inhabitant of our lakes both east and west of the Mississippi, makes its appearance in Nevada early in May, and by the 10th of the month is very generally dispersed.

A bird of the sloughs and reedy marshes, wherever found, its habits differ in but few and unimportant particulars. The character and extent of its nest vary somewhat with the locality it inhabits. Thus Dr. Coues tells us that it builds no nest of its own, but finds the matted *débris* of weeds a sufficient protection for its eggs, while Mr. Nelson's experience near Chicago was in effect that it invariably builds a substantial nest of its own, whatever the foundation may be. In one particular the custom of the species, wherever found, seems to be very uniform, namely, for all the pairs in a given locality to adopt the same plan, which is naturally determined by surrounding circumstances. In Nevada the method of nidification appears to be various, the nests in some neighborhoods being placed among the waving grass in a tolerably dry situation; in others, on firm tussocks; in others still, on beds of matted tules. In any event the formation of a certain amount of material of the bird's own gathering into some sort of a nest seems in this region to be the rule. I may note here some curious nesting sites selected by a large colony of these terns, which had established themselves in a slough that contained enough open water to form the home of numerous grebes (*P. auritus californicus*). The nests of the grebes, from which the young had departed not long before, had been utilized by the terns, and hasty gatherings of bits of dried rushes and the like had been placed upon the half-decayed and wholly filthy masses to receive their eggs. The utter lack of fastidiousness of the terns was further exemplified in the fact that in nearly every case their own eggs lay in close proximity to the rotten and abandoned eggs of the first occupants. In fact, in one or two instances the terns must have found it difficult to incubate their own eggs without partially covering one or more of these. At this date (July 24) some of the eggs were in the advanced stages of incubation, while others had been hatched. The most vociferous of the family under every-day circumstances, such an occasion as the present is sure to call out all the bird's powers of noisy vituperation. The cries of the parents as they flew close down to the nests had the desired effect of causing the young to hastily abandon the nests and seek shelter in the grass. One old bird that was sitting on an egg from which the bill of the imprisoned chick was just escaping refused to leave her charge at this critical juncture, and actually permitted me to approach in plain sight and take her in my hand.

Fish forms an unimportant item in the bill of fare of this species, as, unlike others of the family, it feeds in great part upon insects, which it takes in various ways, mostly as they fly from the grasses.

The species is present in Nevada during the latter part of August in somewhat diminished numbers, but in September all leave for the south.

DESCRIPTION OF NESTLING.—Head above smoky brown, the same color prevailing below, but becoming darker across the jugulum and lighter on abdomen; sides of head and loral region white; back and sides of body pale cinnamon brown, interspersed with irregular patches of black; bill black; feet brownish.

## COLYMBIDÆ—Divers.

### COLYMBUS Linnæus.

*C. torquatus* (Brunn.). Great Northern Diver.

From information received from various sources I had been led to consider this diver as of rather uncommon occurrence in the waters of this region. During the past season, however, it was met with several times on Eagle Lake, Cal., where a number of pairs breed regularly, and the same is true, I think, of Goose Lake, where, at any rate, the species was observed by our party during the late summer.

## PODICIPIDÆ—Grebes.

### PODICEPS Latham.

*P. occidentalis* (Lawr.). Western Grebe.

None the less striking because familiar is the appearance of this large grebe as seen upon the extensive lakes of Nevada, and the country generally west of the Rocky Mountains. At what time in the spring it makes its appearance in these latitudes I do not know. On the occasion of my first visit to Washoe Lake about the middle of May the water was dotted with water birds, and conspicuous among them, as well by its elegance of form as by its graceful motions, was this grebe. Subsequently, when in turn I visited the several lakes lying to the northward, I found it an abundant inhabitant of them all. Indeed, with the exception of Lake Tahoe, I know of no large body of water in the far West that is exempt from its presence. The high elevation of Tahoe, over 6,000 feet, probably accounts for the absence of the bird, as in all the other mountain lakes of less elevation I have always found it present in abundance.

There is a pretty close correspondence in the character of the food, the manner of obtaining it, and in the habits of nidification of the various species of this family, and my observations have not shown that the western grebe possesses any very marked individuality in these respects, unless such as arises from its great size and superior prowess in manner of obtaining food. The largest of our species, the present bird excels all the others in natatorial powers, and in its ability to remain a long time submerged, in which particular it almost rivals the loon. It is probable, therefore, that this grebe is able to avail itself of its remarkable powers in the capture of fish, and it hence lives more upon them than do the other smaller and less powerful species. But fish do not, I think, form by any means its principal diet. The larvæ of all aquatic insects, various worms and leeches, as also some kinds of aquatic plants, make up its chief dependence.

The western grebe is a wonderfully quick diver, as I have had occasion to learn when after specimens, and I have found it almost impossible to kill the old and wary birds even at very short range, provided the bird was not taken unawares and could see the flash of the gun. However true the aim, and whatever the precaution as to the place aimed at, the leaden pellets when they reached the spot found only empty space, where a moment before was to be seen the long, snaky neck of the cunning diver.

It is about the 1st of June when the various species of grebes begin to think of their domestic duties, and if they be watched now they will be found to have gathered together into loose companies, which are to colonize together later on, and to spend much of their time in swimming back and forth in a rather excited manner just off one of the many clumps of tules that grow around the margins of most of the western lakes. The shallow depths about such form, it is true, favorite hunting grounds at all seasons, but around the comparatively few spots that possess the necessary qualifications for nesting purposes the concentration of the birds will be more marked as well as more persistent. The thicker tangled recesses among the tules are shunned, and only those spots among the season's fresh growth selected, where the tall reeds, while affording ample protection as well from the waves of the open lake as from chance observation, will yet admit of unimpeded progress in swimming to and from the nest. Such a place found numerous pairs center in and form a sort of independent colony, and the preparations for the nest are leisurely gone on with. A few of the surrounding tule-stems are perhaps broken off or bent down, and other reedy material gathered and laid in a pile, the structure being ready for occupation when a slightly hollowed and homogeneous mass of this is raised so as to fully clear the surface of the water.

None of the many nests I have examined, either of this or the other species, have been moored as described by some authors. They have usually been perfectly free, except in so far as the reeds constituting a hedge about them offer a complete check to the chance of their floating off. Occasionally, it is true, a few of the surrounding stems have been bent down and made to enter into the composition of the nest. But this is rather rare, and is apparently to be looked upon as an entirely accidental circumstance, so far as any intention of anchoring the structure is concerned.

A less promising place to deposit eggs than the structure described can scarcely be imagined. The material, which is mostly gathered from the water, is muddy and soggy, and how it is possible to hatch eggs on such surroundings is a mystery to all but the grebes. The problem appears to be easy enough of solution to them, and solve it they do in a most satisfactory manner. I have never been successful in my efforts to catch sight of a grebe on its nest, and partly on this account, partly from the peculiar character of the nest itself, have been led to surmise that much of the labor of incubation is shirked by the birds of this family and is delegated to the warmth of the sun's rays, aided, perhaps, by the heat which arises from the decomposing nest material. Like other species, as the eared grebe, the present bird covers up the eggs in its absence, although occasionally I have found them exposed to view. I have never found more than four eggs to a nest of this species, but presume that this number does not represent the full complement.

The young begin to appear about the first of July, but many pairs at this date will be found to still be incubating. The chicks appear to leave the nest almost as soon as hatched, and their history at this early stage is full of interest. One need only push his boat through the tules at this season to find himself rewarded by the sight of some domestic scenes that will well repay his trouble, and will perhaps give him a higher idea of these birds of "low instinct" than is usually accorded them. The reedy recesses are full now of quaint noises, not heard at other seasons. The faint quackings of the young ducklings convoyed by their watchful parents, the harsh notes of the coots calling to their numerous progeny, the piping of rails, and the querulous sputtering notes of the ever busy marsh wrens, are blended into a common melody, that now swells into full chorus, now dies away into confused murmurs under the fitful midsummer's breezes. But notes, too, other than the above are to be made out in the confused gabble, viz: the high piping call of the grebes, and, if he manages adroitly, the observer will find himself directly in the midst of a family group or groups containing all the birds just mentioned. His appearance will be the signal for a hasty scattering of the startled community, but, whatever of the scene he may fail to take in, let him not overlook our grebe just now. At the first sign of danger the pair of old birds have warned the young, that respond with feeble pipings, and at the call placing themselves on the broad flat backs of their parents, who have ranged up alongside for the purpose they are transported to a place of safety. No more beautiful and touching sight can be imagined than that presented by the downy little creatures as they huddle close up to the old one's neck, and give themselves trustfully up to its protection. Both parents share equally in the care of the young, part of the brood accompanying one, part the other. In this manner, they are carried about from feeding ground to feeding ground, or removed when danger threatens. Even at this very early age the chicks, under emergency, are wonderfully adept at diving and swimming, and to catch one uninjured is a matter of no little difficulty.

A brief description of the young in the downy stage, hitherto undescribed, is subjoined. First stage: Body above, dark sooty brown, lightest along sides. Head and hind neck light ashy plumbeous, in contrast to the under parts, which are pure white. Bill black, extreme tip light yellow.

When about half-grown, and while still in the down, the young differ considerably from the above in color. The head above is then of a blackish brown, and the down on hind neck shows the same color at base. It would appear that the growth of down is continuous for a considerable period, the ends being constantly worn away by attrition, and that its color just prior to the replacement by the true feathering corresponds with that of the latter.

*P. auritus californicus* (Heerm.). Eared Grebe.

This diminutive species appears to reach its maximum of abundance only as we approach the west coast. In Nevada, Oregon, and California, it is by far the most numerously represented of the family, and may be found at the right season on any and all the lakes and ponds of this region, where exist the proper nesting facilities. Though apparently absent in summer over much of the interior region proper, through all which, however, it migrates, it has been ascertained by Dr. Coues to breed abundantly along our northern frontier, as in Dakota, while on the other hand a sizable colony was found breeding in Southern Colorado, by myself. This may prove to be an extreme point in its summer range, but I think not, and that there is at least a probability of its occurrence still farther south, in Arizona.

Much of the account of the breeding habits of the previous species will apply equally well to the present bird. The nests are the same characteristic structures, the only difference being one of size, and the eggs are deposited about the same time. The habit, mentioned elsewhere, of covering the eggs with a perfect screen of weeds seems to be everywhere a constant one with the eared grebe, and I have never found a nest in which the eggs could be seen without first uncovering them.

Both parents share in the care of the young after birth, and, as in the case of the larger species, the young are carried about on their backs. The families are difficult to find at this season, as they rarely visit the open water, but keep sedulously within shelter of the tules, whence their shrill calls may be heard coming from all directions, and yet not a bird, young or old, be seen, unless extreme care be taken in approaching them.

The following is a description of the young:

*First stage.*—Head above black; a faint yellowish white line begins at base of bill, divides on forehead, and passes over either eye to hind neck; the latter is also streaked with white. Body above blackish brown; each down shaft tipped with ash; sides washed with plumbeous. Under parts rosy white.

As will be noticed, the young of this species differs sufficiently from the similar stage in any of the others as to be readily identifiable.

### PODILYMBUS Less.

*P. podiceps* (L.). Pied-bill Grebe.

Although not nearly so abundant as the eared grebe, the "dabchick" is yet abundantly represented on the waters of this region in summer, and doubtless also to a greater or less extent as a resident species. The Pied-bill nests in the same localities as the eared grebe, and in the general particulars of habits the two agree closely.

The young of the present bird have very decided markings about the head, broad white and dark lines being contrasted alternately. On the back of the head are several irregular patches of bright rufous.

# APPENDIX PP.

## ANNUAL REPORT OF CAPTAIN JAMES F. GREGORY, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1879.

### EXPLORATIONS AND SURVEYS MILITARY DIVISION OF THE MISSOURI.

HEADQUARTERS MILITARY DIVISION OF THE MISSOURI,
OFFICE CHIEF ENGINEER,
*Chicago, Ill., July* 10, 1879.

GENERAL: I have the honor to submit the following report upon the operations conducted under my charge for the portion of the last fiscal year beginning December 28, 1878, and ending June 30, 1879. Upon the former date I reported to the Lieutenant-General commanding this division, in compliance with paragraph 7, Special Orders No. 256, dated Headquarters of the Army, Adjutant-General's Office, Washington, November 26, 1878, and was on same date by him assigned to duty as chief engineer of the division. I found upon arrival here that Lieut. Col. George A. Forsyth, aid-de-camp, had charge of the records and was responsible for the property pertaining to the chief engineer's office, and duly relieved him of them. He had, however, no public funds for disbursement and I have had none since my assignment here. The sum of $50 was, by direction of the Chief of Engineers, allotted from appropriation for surveys for military defenses, for the purchase of a small amount of materials for office use, and this is all that has been expended.

On January 4, last, occurred the fire which partly destroyed the Honoré Building, in which these headquarters are located. Although my office rooms were not burned out, they were deluged with water—the floors of the story above being burned out, and the ceilings and windows of my rooms broken through. The contents of the building which were saved from the fire were removed next day, and in the confusion incident to such a hurried removal a considerable amount of property was lost and more damage done to papers and maps than was caused by the water. The fortnight succeeding the fire was spent in rearranging the records saved, and restoring them, as far as possible, to order and good condition. On March 27, the building having been restored to a state suitable for occupation, our offices were returned to it.

On January 8, I enlisted Frederick A. Petersen in the general service, as topographical assistant, under the provisions of paragraph 1, General Orders No. 62, Headquarters of the Army, Adjutant-General's Office, Washington, July 3, 1877. Under same order, Private George Henckel, Ninth Infantry, was transferred to the general service by paragraph 1, Special Orders No. 21, dated Headquarters Military Division ot the Missouri, Chicago, March 5, 1879, and ordered to report to me for duty, which he did March 11, last. These assistants have been constantly at work in the office since the dates mentioned, and have rendered excellent service.

The current work of the office has been in furnishing information from records; making tracings of and reducing maps for use at division headquarters, and for file and forwarding; correcting, mounting and issuing maps for use of officers on duty at these headquarters and elsewhere in the division.

During three months past Topographical Assistant Henckel has been engaged, in the time allowed from current office duties, in compiling information for and platting it upon "Sheet No. 4, Western Territories." This sheet is upon the same scale as the other sheets of the series, $\frac{1}{2000000}$, and embraces the territory included by the 28° 30′ and 39° 30′ parallels and the 103° and 113° meridians. This sheet has progressed but slowly, because of the constant demands upon the draughtsman's time by current work. It will be continued, but it is impossible to say, under the circumstances, when it will be completed. The amount of labor and time required for making tracings and copies of maps, &c., which pass through this office, is very great.

Since I have been on duty here I have, by Lieutenant-General Sheridan's orders, accompanied him on several tours of inspection; the posts so visited including Fort Robinson and Camp Sheridan, Nebr.; the posts on the Missouri River, between Bismarck and Yankton, Dak.; and Forts Lewis and Marcy, Colorado and New Mexico.

I append a tabular statement showing the number of maps received, completed by hand and issued during the past six months; also, a list showing the number and giving description of tracings and maps made in same time; also, a list showing maps and tracings received from chief engineers of departments.

The need of my office is a moderate amount of money wherewith to employ a draughtsman and to purchase the ordinary materials required. It has been through considerable embarrassment, that I have been able to do even so much as has been done, and it has been accomplished by begging from other departments, and by purchase of materials from my own private means.

Five thousand dollars could be profitably expended during the next fiscal year.

Very respectfully, your obedient servant,

JAMES F. GREGORY,
*Captain of Engineers.*

Brig. Gen. H. G. WRIGHT,
*Chief of Engineers, United States Army.*

### TABULAR STATEMENT OF MAPS RECEIVED, CORRECTED, COMPLETED, MOUNTED, AND ISSUED.

| Disposition. | Title of maps. | | | | | | |
|---|---|---|---|---|---|---|---|
| | United States, showing military departments. | Yellowstone and Missouri Rivers. | Western Territories. | Kansas, Texas, and Indian Territory. | New Mexico. | Indian Territory | Southern Colorado and Northern New Mexico. |
| Received | 16 | 54 | 60 | 20 | 57 | 108 | 3 |
| Corrected | 8 | 23 | 9 | 8 | 7 | 5 | 1 |
| Completed | 8 | 23 | 9 | 8 | 7 | 5 | 1 |
| Mounted | 9 | 3 | 2 | 2 | 1 | 1 | ...... |
| Issued | 9 | 20 | 6 | 6 | 4 | 3 | ...... |

### LIST OF TRACINGS AND MAPS MADE.

2 tracings of Fort Robinson, Nebr., with line of retreat of Cheyennes after their outbreak January 9, 1879.
2 tracings of sketch of route from Wichita, Kans., to Barrel Springs, Ind. T., with itinerary.
1 tracing of country between Missouri River and 50° north latitude, and 104° and 110° west, locating thereon the whereabouts of hostile Indians.
Reduced plan of Fort Custer, Mont.
Reduced topographical sketch of Fort Custer and vicinity.
1 tracing of United States military reservation of Fort Missoula, Mont.
1 tracing of Fort McKinney Reservation.
1 tracing of vicinity of Ysleta, Tex.
1 tracing of reconnaissance by General Brooke between Forts Benton and Assinaiboine.
4 tracings of Indian Territory, from General Land Office map.
1 tracing of Southern Colorado, from Professor Hayden's drainage map.
1 tracing of proposed extension of military reservation of Fort Robinson, Nebr.
1 tracing of proposed reservation at El Paso, Tex.
2 tracings of map of military reservation of Fort Ringgold, Tex.
1 tracing of reservation of Depot McKinney, Wyo.
1 tracing showing proposed telegraph lines in Indian Territory.
1 tracing showing site for post at Henry's Lake, Ind. T.
1 tracing of plan of fourth story of United States post-office and custom house, Chicago.
Corrected 2 maps of the United States. (Rand, McNally & Co.'s edition.)
Mounted for office use, map of Dakota.

### WORK DONE FOR THE QUARTERMASTER DEPARTMENT.

Corrected map of the United States. (R., McN. & Co.'s ed.)
Made 5 tracings and mounted transportation map of Department of Dakota.
Made 3 tracings and mounted transportation map of Department of the Platte.
Made 3 tracings and mounted transportation map of Department of Texas.
1 tracing of plan of fourth story of United States post-office and custom-house, Chicago.

## WORK IN PROGRESS.

### Sheet 4, Western Territories.

### LIST OF MAPS AND TRACINGS RECEIVED FROM CHIEF ENGINEER OFFICERS OF DEPARTMENTS.

*Department of Missouri.*

| Date. | Nature. | Description. | By whom made. |
|---|---|---|---|
| 1879. | | | |
| Feb'y 18 | 1 tracing...... | Battle-ground, September 27, 1878 .................... | Captain Wedemeyer. |
| Feb'y 18 | .... do......... | Toll road cañon, Animas River........................ | Lieutenant Ruffner. |
| Feb'y 27 | .... do......... | United States military reservation of Fort Lewis, Colo., and townsite at Pagosa Springs. | Lieutenant Ruffner. |
| March 5 | .... do......... | Route of battalion Ninth Cavalry, Companies C and D, under command of Captain Parker. | Captain Parker. |
| March 5 | .... do......... | Topographical sketch of part of Western Colorado and Eastern Utah, showing route of Lieutenant Humphrey, Ninth Cavalry. | Lieutenant Humphrey. |
| March 10 | .... do......... | New road from Wichita, Kans., to Barrel Springs, Ind. T. | Lieut. C. H. Heyl. |
| March 20 | .... do......... | Route from Fort Garland, Colo., to Santa Fe, N. Mex., and from San Juan, N. Mex., to Alamosa, Colo. | Lieutenant Steadman. |

*Department of Dakota.*

| | | | |
|---|---|---|---|
| March 21 | 1 tracing...... | Topographical map of Fort Custer, Mont ............ | Private Lewis Werver, Second Cavalry. |
| March 21 | .... do......... | Plan of Fort Custer, Mont ............................ | |
| March 28 | .... do......... | Reconnaissance from Fort Keogh to Fort Buford.... | Lieutenant Maguire. |
| March 28 | .... do......... | Reconnaissance of the Owl River...................... | Lieutenant Hoffman. |
| April 2 | .... do......... | Military reservation, Fort Keogh...................... | Lieutenant Maguire. |
| April 19 | .... do......... | Plan of Fort Keogh, Mont ............................ | Lieutenant Maguire. |
| April 26 | 1 map......... | Department of Dakota, 1878.......................... | Lieutenant Maguire. |

*Department of Texas.*

| | | | |
|---|---|---|---|
| April 8 | 1 tracing...... | Field operations Company K, Tenth Cavalry, September and November, 1878. | Lieutenant Read. |
| April 22 | 1 map......... | Western Texas, December, 1878 (photograph) ....... | Captain Livermore. |
| May 8 | 1 tracing...... | Scout of detachment Company E, Tenth Infantry, from Fort Griffin, Tex., to vicinity of Pease River. | Lieutenant Winston. |
| June 23 | ....do......... | Scout by Lieut. J. L. Bullis, Twenty-fourth Infantry, from Fort Clark, Tex., through Texas and in New Mexico in the spring of 1879. | Lieutenant Bullis. |

*Department of the Platte.*

| | | | |
|---|---|---|---|
| March 10 | 1 tracing...... | Military reservation, Camp Sheridan, Nebr ......... | Captain Stanton. |
| May 8 | 1 map......... | Reconnaissances of routes in Department of the Platte, 1875, 1876, and 1877. | Captain Stanton. |

*Division of the Pacific.*

| | | | |
|---|---|---|---|
| April 2 | 2 maps........ | Sheets two and eight of Arizona Territory........... | Lieutenant Toney. |
| April 2 | .... do......... | Scout of Lieut. Geo. S. Wilson, Twelfth Infantry, near headwaters of Salmon River, Indian Territory, in the summer of 1878. | Lieutenant Palfrey. |

# APPENDIX Q Q.

## ANNUAL REPORT OF CAPTAIN W. S. STANTON, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1879.

### EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF THE PLATTE.

HEADQUARTERS DEPARTMENT OF THE PLATTE,
ENGINEER OFFICE,
*Fort Omaha, Nebr., July* 4, 1879.

GENERAL: I have the honor to submit the following report as engineer officer of this military department for the fiscal year ending June 30, 1879.

My last annual report exhibited the progress, and the results thus far, of a system of reconnaissances designed for such a revision of the department map and to secure such information as the needs of the service more immediately demand, especially in regard to present and future routes.

The region of active service, where such work is most needed, is that part of the department lying north of the Union Pacific Railroad and west of the one hundredth meridian, embracing about 160,000 square miles. Four lines of telegraph penetrate it from the railroad at intervals of about 130, 180, and 190 miles. The eastern and western of these lines extend beyond the northern boundary of the department to Fort Custer and Helena, Mont., while the two intermediate ones penetrate to distances respectively at Camp Stambaugh and Fort McKinney, of 100 and 225 miles. These lines of telegraph afford excellent and unusual facilities for reconnaissances by providing telegraphic longitudes for their initial and closing points, and frequently checked chronometer rates for chronometric longitudes at intermediate camps. They thus impart to the work an accuracy sufficient not only for all present uses, but to give it in a considerable degree a permanent value for use hereafter in connection with a systematic survey of the West.

These reconnaissances have been made thus far where most urgently needed, in that part of the department which was either the base or seat of operations against the Sioux Indians in 1876 and which is still the region of the most activity in the movement of troops and supplies. But few if any of the routes there were before correctly mapped and none of them had been measured, at least the results of no reliable measurements were available for payments by the Pay and Quartermaster's Departments or for arranging and conducting military movements. The printed itineraries and tables of distances resulting have been supplied to various disbursing and accounting officers here and in Washington, by whom they have been sought, and officers serving with troops have conclusively asserted their usefulness in the field.

The operations against the Bannock and Shoshonee Indians in Southeastern Idaho in the spring of 1878 disclosed the fact that the map of that Territory is quite out of date and defective for campaign purposes, revealing a want of information regarding routes and localities hampering to the department commander and his staff here and to officers in the field there, and strikingly exemplified the necessity for pushing the reconnaissances to the western limit of the department as soon as practicable.

Again, on the escape of the Cheyenne Indians northward from the Indian Territory last autumn, the search by the troops for a band of them in the great sand-hill region of this State evinced the need of extending the reconnaissances eastward to secure information of the most favorable lines of approach and entrance to the sand hills, and of the location of the most probable resorts for Indians among them. The use of exploring that rather obscurely known and difficult region is further apparent from the present proximity to it of the Sioux and from the possibility that they likewise may resort to it if again hostile and pursued by the troops.

These reconnaissances, which are so clearly of immediate utility to the service, are made with means as exclusively military as consistent with efficient and accurate work and with a true economy, which exacts such an application of the means employed (personal, escort, and transportation) as will secure the largest and best results. The only service not rendered by persons either commissioned or enlisted is that performed by one civilian as topographer and assistant in the field and as principal draughtsman in the office at $100 per month, a sum well expended and as well earned by exacting and unremitting labor.

This much-needed map-work, based upon careful reconnaissances and all available information from railroad, boundary, and land surveys, is the chief and foremost duty of a department engineer, in which, with suitable means, he could constantly render advantageous and remunerative service to the government.

I regret to report that the utter want of funds in this office has compelled the discontinuance of reconnaissances during the year, and consequently that no material progress has been made with the department map.

Throughout the year this department has had neither a dollar of engineer funds nor an engineer soldier. A detachment of selected engineer troops has long been sought, with the design, after carefully instructing them, of distributing them among the more important posts in the department, to be at hand to accompany the marches of the various columns and detachments for the purpose of making with odometer and compass a careful survey of their trails. This appears to be the only method of securing from these movements information sufficiently complete, clear, and accurate, and sufficiently trustworthy to embody upon the map.

The following is a summary of what has been done in the office subsequently to the first two months of the fiscal year, which were occupied in completing the computations of altitudes, preparing the profiles of routes and plates of meteorological curves, and finishing the map, all of which accompanied my last annual report.

The reduction of the meteorological observations taken at Fort Laramie during the reconnaissance of the preceding year has been completed. The results of these observations, which were taken hourly from July 31 to November 2, 1877, are embodied in the three following tables and in the curves on the two plates herewith, which give hourly for each of the three periods from July 31 to August 31, September 1 to 30, and October 1 to November 2, the mean, each, of the temperature, difference between the wet and dry bulb thermometers, force of vapor, relative humidity, and horary correction of the barometer.

ANDTHS
OF
URATION

*Summary of hourly observations at Fort Laramie, Wyoming, from July* 31 *to November* 2, 1877.

**Latitude 42° 12′ 01″; altitude above sea level, 4,241 feet.**

*From July* 31 *to August* 31.

| Hour. | Horary correction of barometer. | Temperature (Fahr.). | Mean difference wet and dry thermometer. | Force of vapor. | Relative humidity. |
|---|---|---|---|---|---|
| 7 a. m | —. 043 | 66. 9 | 10. 4 | . 344 | . 528 |
| 8 a. m | —. 034 | 69. 4 | 11. 5 | . 355 | . 500 |
| 9 a. m | —. 042 | 71. 8 | 12. 5 | . 360 | . 466 |
| 10 a. m | —. 032 | 74. 9 | 15. 0 | . 354 | . 415 |
| 11 a. m | —. 018 | 77. 8 | 17. 2 | . 348 | . 371 |
| 12 m | —. 002 | 79. 6 | 19. 3 | . 330 | . 333 |
| 1 p. m | +. 015 | 80. 9 | 20. 2 | . 329 | . 319 |
| 2 p. m | +. 027 | 81. 8 | 21. 0 | . 324 | . 306 |
| 3 p. m | +. 035 | 82. 1 | 21. 6 | . 316 | . 298 |
| 4 p. m | +. 041 | 82. 1 | 21. 4 | . 321 | . 306 |
| 5 p. m | +. 042 | 82. 0 | 21. 3 | . 323 | . 317 |
| 6 p. m | +. 043 | 81. 2 | 20. 2 | . 333 | . 326 |
| 7 p. m | +. 034 | 79. 1 | 18. 5 | . 339 | . 354 |
| 8 p. m | +. 024 | 76. 7 | 16. 6 | . 347 | . 391 |
| 9 p. m | +. 015 | 75. 2 | 15. 8 | . 343 | . 405 |
| 10 p. m | +. 005 | 73. 6 | 14. 9 | . 339 | . 417 |
| 11 p. m | —. 002 | 72. 0 | 13. 8 | . 340 | . 444 |
| 12 p. m | —. 008 | 70. 8 | 13. 1 | . 339 | . 456 |
| 1 a. m | —. 005 | 69. 2 | 12. 2 | . 337 | . 477 |
| 2 a. m | —. 007 | 68. 1 | 11. 5 | . 338 | . 494 |
| 3 a. m | —. 013 | 66. 9 | 10. 5 | . 341 | . 520 |
| 4 a. m | —. 015 | 65. 8 | 10. 0 | . 339 | . 531 |
| 5 a. m | —. 025 | 64. 7 | 9. 3 | . 336 | . 554 |
| 6 a. m | —. 040 | 65. 0 | 9. 3 | . 341 | . 556 |
|  | .......... | 74. 1 | 15. 3 | . 338 | . 420 |

*September* 1 *to* 30.

| Hour. | Horary correction of barometer. | Temperature (Fahr.). | Mean difference wet and dry thermometer. | Force of vapor. | Relative humidity. |
|---|---|---|---|---|---|
| 7 a. m | —. 030 | 57. 5 | 7. 7 | . 282 | . 587 |
| 8 a. m | —. 029 | 60. 2 | 8. 9 | . 289 | . 554 |
| 9 a. m | —. 028 | 62. 5 | 10. 1 | . 295 | . 523 |
| 10 a. m | —. 027 | 64. 6 | 11. 6 | . 290 | . 481 |
| 11 a. m | —. 015 | 66. 9 | 13. 0 | . 290 | . 451 |
| 12 m | +. 007 | 68. 7 | 14. 0 | . 294 | . 430 |
| 1 p. m | +. 022 | 69. 6 | 14. 7 | . 290 | . 415 |
| 2 p. m | +. 032 | 70. 5 | 15. 4 | . 289 | . 402 |
| 3 p. m | +. 044 | 71. 0 | 15. 8 | . 287 | . 392 |
| 4 p. m | +. 045 | 71. 0 | 15. 9 | . 286 | . 391 |
| 5 p. m | +. 045 | 70. 6 | 15. 4 | . 290 | . 401 |
| 6 p. m | +. 042 | 69. 2 | 14. 1 | . 298 | . 427 |
| 7 p. m | +. 032 | 67. 4 | 13. 1 | . 296 | . 449 |
| 8 p. m | +. 009 | 65. 5 | 12. 3 | . 287 | . 463 |
| 9 p. m | +. 001 | 64. 0 | 11. 5 | . 285 | . 481 |
| 10 p. m | —. 009 | 62. 6 | 10. 9 | . 280 | . 498 |
| 11 p. m | —. 012 | 60. 9 | 9. 7 | . 279 | . 525 |
| 12 p. m | —. 012 | 59. 8 | 9. 3 | . 275 | . 540 |
| 1 a. m | —. 015 | 58. 3 | 8. 8 | . 272 | . 556 |
| 2 a. m | —. 015 | 57. 1 | 8. 2 | . 269 | . 573 |
| 3 a. m | —. 016 | 55. 9 | 7. 8 | . 271 | . 606 |
| 4 a. m | —. 018 | 54. 8 | 6. 7 | . 272 | . 631 |
| 5 a. m | —. 020 | 53. 7 | 6. 3 | . 268 | . 633 |
| 6 a. m | —. 026 | 53. 3 | 6. 3 | . 262 | . 632 |
|  | .......... | 63. 1 | 11. 1 | . 283 | . 502 |

*October* 1 *to November* 2.

| Hour. | Horary correction of barometer. | Temperature (Fahr.). | Mean difference, wet and dry thermometer. | Force of vapor. | Relative humidity. |
|---|---|---|---|---|---|
| 7 a. m | —.023 | 41.6 | 4.8 | .175 | .660 |
| 8 a. m | —.029 | 44.8 | 5.5 | .191 | .637 |
| 9 a. m | —.030 | 47.0 | 6.4 | .196 | .606 |
| 10 a. m | —.023 | 48.6 | 7.0 | .201 | .585 |
| 11 a. m | —.016 | 50.2 | 7.8 | .203 | .361 |
| 12 m | +.008 | 51.5 | 8.7 | .200 | .532 |
| 1 p. m | +.027 | 52.9 | 9.3 | .204 | .522 |
| 2 p. m | +.038 | 53.6 | 9.7 | .203 | .512 |
| 3 p. m | +.040 | 54.0 | 9.9 | .204 | .509 |
| 4 p. m | +.035 | 53.9 | 10.2 | .199 | .500 |
| 5 p. m | +.030 | 53.0 | 9.4 | .204 | .524 |
| 6 p. m | +.019 | 51.6 | 8.8 | .201 | .539 |
| 7 p. m | +.009 | 50.4 | 8.2 | .199 | .552 |
| 8 p. m | +.002 | 48.7 | 7.2 | .198 | .583 |
| 9 p. m | —.008 | 47.2 | 6.8 | .192 | .592 |
| 10 p. m | —.010 | 46.1 | 6.4 | .189 | .607 |
| 11 p. m | —.010 | 45.0 | 6.0 | .187 | .621 |
| 12 p. m | —.007 | 44.4 | 5.7 | .185 | .631 |
| 1 a. m | —.004 | 43.5 | 5.1 | .186 | .650 |
| 2 a. m | —.004 | 42.6 | 4.7 | .186 | .669 |
| 3 a. m | —.001 | 41.6 | 4.3 | .184 | .682 |
| 4 a. m | —.011 | 40.4 | 4.0 | .179 | .691 |
| 5 a. m | —.015 | 39.6 | 3.9 | .172 | .681 |
| 6 a. m | —.018 | 39.3 | 4.1 | .166 | .672 |
|  |  | 47.1 | 6.8 | .192 | .598 |

The six original sheets on a scale of 1:200,000 of the map which was printed on a scale of 1:900,000 with the report of last year, have been finished by inking and lettering them and adding the topography. They are on a suitable scale for plotting the field notes, and are retained in the office in order that reliable reconnaissances which may be made in future in the region which they cover may be plotted upon them. All reliable information secured within their limits will thus gradually be accumulated on these sheets, which will contain only work known to be correct from actual survey in the field.

The compass and odometer notes of the 1,300 miles of routes embraced in the reconnaissance of 1877 have been reduced with the traverse table, and the latitudes and departures thus found between the various camps have been compared with the same co-ordinates as determined astronomically. This reduction and comparison were made to show with accuracy how closely the trail as surveyed with the compass and odometer would plot between the astronomical points, and to give an approximate idea of the reliability of odometer measurement of routes. The comparison is given in the appended table.

Excluding cases where the co-ordinates make an angle of nearly 90° with the route which involve the largest error arising from want of refinement in taking the courses, and excluding unusually tortuous routes in very hilly country, an examination of the table will show that the average excess by odometer measurement is about 4½ per cent. This excess would seem to be no greater than that due to the tortuosity of the trail in each course and to the slope.

Nearly a month was spent during the winter in very carefully examining and correcting, within the limits of this military department, a photographic copy of the northeastern sheet of the map of the Western Territories being compiled in the Engineer Department, which was sent to this office for that purpose.

The collection, from the General Land Office and from the office of the Adjutant-General of the Army, of information relating to the various military reservations in this department which has been in progress for some time past has been completed, and from the mass of papers thus secured and filed in the office a comprehensive, clear, and quite voluminous record has been made of the various orders of the President by which the reservations have been declared or enlarged, of the acts of Congress by which they have been reduced or relinquished, and of the general orders and most important correspondence from the War Department and division and department headquarters relating thereto.

From this information, with that previously in the office, revised plots have been prepared of the nineteen military reservations in the department on an uniform scale of two inches to one mile (1:31680) and tracings of them have been made for file at the headquarters of the various posts. Full information is clearly inscribed on the plot of each reservation, describing its boundaries, specifying the various orders by which it was established, when and by whom it was surveyed, and giving the latitude, longitude, altitude, and magnetic declination of the post.

The aggregate area of land in the department reserved, leased, and purchased for military purposes is 306.2 square miles.

The above compilation and plots are fortunately at hand to favor a ready compliance with a request for information of this precise character recently made by the War Department upon the department commander and referred to this office.

The collection of information has been in progress for the revision of the "tables of distances and itineraries of routes" in this department necessary on account of changes which have occurred since their preparation in December, 1877. The more important of these changes are as follows: The post of Fort McKinney has been moved 51.6 miles by road west of north from its former site on Powder River to the Clear Fork of that stream. The posts of Fort Bridger, Camp Stambaugh, North Platte, and the sub-post of Hat Creek have been abandoned. The designations of Camps Robinson and Douglas and of Sidney and Omaha Barracks have been changed to forts, and the name of Camp Brown has been changed to Fort Washakie. A new route has been opened by the troops from Rawlins, on the Union Pacific Railroad, via Whisky Gap, Muddy Creek, and Sweetwater River, to Fort Washakie, Wyo., materially shortening the line of transportation from the east to that post. The Utah Northern Railroad (narrow gauge) has been extended 102 miles from Franklin, to Blackfoot, Idaho, reducing the distance between Fort Hall and railroad communication from 104 to 12 miles. The extension of the Utah Southern Railroad is in progress southward to a point nearer Fort Cameron, Utah. A line of telegraph has been completed by the troops from Deadwood across the northeast corner of this department to the Little Missouri River and extended by detachments from Forts Keogh and Custer, Mont., to those posts. The Spotted Tail and Red Cloud Agencies of the Sioux Indians have been moved from the Missouri River, respectively, to the South Fork of White River at the mouth of Rosebud Creek, and to Big White Clay Creek at the mouth of Wolf Creek. This location of that powerful tribe in a degree imperils the cattle interests on the Niobrara River, in the northern part of this department, and causes a necessity for reconnaissances to secure information needed in the service which the troops are liable to be called upon to render in protecting that region. For this latter purpose the construction at once of a new post in the vicinity of the intersection of the Niobrara by the 100th meridian is probable.

Thirty-two copies of the "tables and itineraries," 359 maps, and 153 reports, 140 of which also contain maps, have been issued.

Drawing materials to the amount of $35.80 have been purchased and supplied to the office by the Engineer Department, which, excepting the maps and reports supplied for issue, is the entire amount of engineer funds applied in this military department during the year.

Very respectfully, your obedient servant,

W. S. STANTON,
*Captain of Engineers, Chief Engineer of Department.*

The CHIEF OF ENGINEERS, U. S. A.

*A comparison of the latitudes and departures between camps, found with the traverse table from odometer and compass notes, with the same co-ordinates as determined astronomically.*

| Route. | Latitude. | | | Departure. | | | Remarks. |
|---|---|---|---|---|---|---|---|
| | With odometer and compass. | With sextant. | Difference. | With odometer and compass. | With sextant and chronometer. | Difference. | |
| Cheyenne, Wyo., to— | | | | | | | |
| Chugwater Creek, Wyo | 42.99 | 43.10 | 0.11 | 0.68 | 1.03 | 0.35 | |
| Chug Springs, Wyo | 16.65 | 15.91 | 0.74 | 0.17 | 0.69 | 0.52 | |
| Fort Laramie, Wyo | 15.33 | 14.72 | 0.61 | 15.01 | 14.50 | 0.51 | Astronomical camp near post. |
| | 74.97 | 73.73 | 1.24 | 14.16 | 12.78 | 1.38 | |
| Fort Laramie, Wyo., to— | | | | | | | |
| Government Farm, Wyo | 12.04 | 11.75 | 0.29 | 1.42 | 0.70 | 0.72 | |
| Rawhide Creek, Wyo | 12.60 | 12.08 | 0.52 | 3.73 | 3.08 | 0.65 | |
| Hat Creek, Wyo | 27.73 | 26.27 | 1.46 | 8.61 | 8.60 | 0.01 | |
| | 52.37 | 50.10 | 2.27 | 10.92 | 10.98 | 0.06 | |
| Hat Creek, Wyo., to— | | | | | | | |
| Lance Creek, Wyo | 28.16 | 27.60 | 0.56 | 0.79 | 1.03 | 0.24 | |
| South Cheyenne River, Wyo | 16.80 | 15.77 | 1.03 | 8.16 | 8.88 | 0.72 | |
| Beaver Creek Valley, Wyo | 22.61 | 23.24 | 0.63 | 2.53 | 2.71 | 0.18 | |
| Cold Springs, Dak | 19.28 | 18.14 | 1.14 | 4.35 | 3.31 | 1.04 | |
| Whitewood Gulch, Dak | 14.43 | 13.98 | 0.45 | 13.76 | 14.64 | 0.88 | |
| | 101.28 | 98.74 | 2.54 | 29.59 | 30.57 | 0.98 | |
| Deadwood, Dak., to— | | | | | | | |
| Spearfish Creek, Dak | 9.43 | 8.44 | 0.99 | 7.14 | 6.56 | 0.58 | Country excessively rough and route very tortuous. |
| Redwater Creek, Wyo | 3.53 | 3.02 | 0.51 | 11.90 | 11.76 | 0.14 | |
| Gillies Creek, Wyo | 7.45 | 6.21 | 1.24 | 26.25 | 25.38 | 0.87 | |
| Belle Fourche River, Wyo | 5.85 | 4.01 | 1.84 | 8.77 | 7.55 | 1.22 | |
| Belle Fourche River, Wyo | 16.23 | 14.83 | 1.40 | 15.38 | 15.91 | 0.53 | |
| A swale, Wyo | 23.88 | 22.27 | 1.61 | 28.47 | 26.91 | 1.56 | |
| A small brook, Wyo | 15.00 | 14.40 | 0.60 | 12.86 | 12.58 | 0.28 | |
| Fort McKinney, Wyo | 10.07 | 9.44 | 0.63 | 19.95 | 19.16 | 0.79 | Part of route very tortuous. |
| | 45.37 | 40.81 | 4.56 | 130.72 | 125.81 | 4.92 | |

*A comparison of the latitudes and departures between camps, &c.*—Continued.

| Route. | Latitude. | | | Departure. | | | Remarks. |
|---|---|---|---|---|---|---|---|
| | With odometer and compass. | With sextant. | Difference. | With odometer and compass. | With sextant and chronometer. | Difference. | |
| Fort McKinney, Wyo., to— | | | | | | | |
| Fort Fetterman, Wyo | 66.94 | 65.18 | 1.76 | 39.31 | 38.69 | 0.62 | |
| Fort Fetterman, Wyo., to— | | | | | | | |
| A small brook, Wyo | 39.82 | 37.60 | 2.22 | 11.42 | 11.67 | 0.25 | |
| Rock Creek Station, Wyo | 31.84 | 31.43 | 0.41 | 7.78 | 8.14 | 0.36 | |
| | 71.66 | 69.03 | 2.63 | 19.20 | 19.81 | 0.61 | |
| Rock Creek Station, Wyo., to— | | | | | | | |
| North Laramie River, Wyo | 24.41 | 23.62 | 0.79 | 23.69 | 24.99 | 1.30 | |
| Southeast base of Laramie Peak, Wyo | 4.65 | 4.37 | 0.28 | 0.90 | 0.25 | 0.65 | |
| Laramie River, Wyo | 7.19 | 6.29 | 0.90 | 35.62 | 34.91 | 0.71 | Road rather tortuous. |
| Fort Laramie, Wyo | 3.86 | 3.18 | 0.68 | 8.51 | 7.47 | 1.04 | Road rather tortuous. |
| | 25.73 | 24.84 | 0.89 | 68.72 | 67.74 | 0.98 | |
| Fort Laramie, Wyo., to— | | | | | | | |
| Rawhide Creek, Wyo | 15.15 | 16.77 | 1.62 | 9.39 | 10.42 | 1.03 | |
| Niobrara River, Nebr | 9.48 | 8.80 | 0.68 | 20.29 | 20.79 | 0.50 | |
| Fort Robinson, Nebr | 7.34 | 6.39 | 0.95 | 24.70 | 24.73 | 0.03 | |
| | 31.97 | 31.96 | 0.01 | 54.38 | 55.94 | 1.56 | |
| Fort Robinson, Nebr., to— | | | | | | | |
| Spring Creek, Dak | 91.47 | 88.80 | 2.67 | 13.49 | 13.68 | 0.19 | |
| Big Spring Creek, Dak | 23.38 | 24.19 | 0.81 | 12.10 | 12.11 | 0.01 | |
| Oak Grove Creek, Dak | 10.21 | 10.12 | 0.09 | 8.55 | 8.23 | 0.32 | Country rough and road tortuous. |
| Whitewood Gulch, Dak | 7.52 | 6.40 | 1.12 | 8.27 | 6.77 | 1.50 | |
| | 117.55 | 116.71 | 0.84 | 15.43 | 13.43 | 2.02 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Deadwood, Dak., to—** | | | | | | | |
| A small creek, Dak | 34.51 | 33.25 | 1.26 | 0.06 | 0.83 | 0.77 | |
| Custer City, Dak | 9.22 | 8.89 | 0.33 | 5.10 | 5.00 | 0.10 | |
| | 43.73 | 42.14 | 1.59 | 5.16 | 5.83 | 0.67 | |
| **Custer City, Dak., to—** | | | | | | | |
| South Cheyenne River, Dak | 32.65 | 31.63 | 1.02 | 10.11 | 11.71 | 1.60 | |
| Indian Creek, Nebr | 22.52 | 21.93 | 0.59 | 13.28 | 10.62 | 2.66 | |
| Hat Creek, Wyo | 4.73 | 3.97 | 0.76 | 15.25 | 14.96 | 0.29 | |
| | 59.90 | 57.53 | 2.37 | 38.64 | 37.29 | 1.35 | |
| **Hat Creek, Wyo., to—** | | | | | | | |
| A small creek, Nebr | 5.19 | 6.36 | 1.17 | 17.64 | 17.12 | 0.52 | Road tortuous. |
| A small creek, Nebr | 6.21 | 4.80 | 1.41 | 17.75 | 16.24 | 1.51 | |
| Fort Robinson, Nebr | 7.43 | 7.33 | 0.10 | 11.46 | 11.28 | 0.18 | |
| | 18.83 | 18.50 | 0.33 | 46.85 | 44.64 | 2.21 | |
| **Fort Robinson, Nebr., to—** | | | | | | | |
| Niobrara River, Nebr | 16.17 | 15.70 | 0.47 | 9.09 | 8.57 | 0.52 | |
| Snake Creek, Nebr | 24.88 | 24.74 | 0.14 | 2.87 | 2.22 | 0.65 | |
| Fort Sidney, Nebr | 66.20 | 64.45 | 1.75 | 17.69 | 14.47 | 3.22 | |
| | 107.25 | 104.89 | 2.36 | 29.65 | 25.33 | 4.32 | |

# APPENDIX R R.

## ANNUAL REPORT OF LIEUTENANT E. H. RUFFNER, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1879.

### EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF THE MISSOURI.

HEADQUARTERS DEPARTMENT OF THE MISSOURI,
OFFICE OF THE CHIEF ENGINEER,
*Fort Lewis, Pagosa Springs, Colo., July* 5, 1879.

SIR: I have the honor to render the following as my annual report for the year ending June 30, 1879: On the 23d of July, 1878, I left Fort Leavenworth for Fort Garland, Colo., and then took charge of the work authorized by the sundry civil expense bill for the current fiscal year upon "military wagon-road from a suitable point on the Denver and Rio Grande Railway to Parrott City, Colo.," for which an appropriation of $5,000 was available. After a preliminary report, which was approved by the department commander, work was authorized by the Secretary of War upon the selected line. This line was due west from Alamoso to the cañon of Cat Creek, and thence up it and across to the cañon of Alamosa Creek. Up this creek the line was a natural water-grade and an easy one until, at 5 miles from the summit, a small tributary was followed to the large park to the west of the summit district, or small town called the Summit.

The pass used was afterwards determined by a survey of the Denver and Rio Grande Railway to be at an elevation of 11,554 feet, Alamosa being 7,500 feet and 54 miles distant. The railway line is, however, longer than the wagon-road, which has an average grade of about 75 feet in the cañon and 300 feet to the mile which, ascending the pass in the steepest portion, or about 5 miles. On the western slope the line follows down the principal tributary of the east fork of the San Juan, down which the grade is very precipitous, probably 400 feet to the mile, for 2 or 2½ miles. After this the grade is better, and at the junction of the two forks a good road is met from that point to Pagosa Springs, 12 miles distant. To use $5,000 in opening 50 miles of new wagon-road and across the main range of the Rocky Mountains is not a very easy task. It was the intention to carry a wagon-track as far as possible, leaving its improvement to some future time. Work continued, therefore, till the exhaustion of the appropriation on the 1st of December, at which time a wagon could go from Alamosa to a point some 6 miles west of the range, leaving some 20 miles of line which are passable only by the trail. The road was at best only passable by wagons, and a further appropriation of $10,000 was asked to complete the work. This has been granted, and work began on the 2d of July, which will result in the completion of the road.

In the fall a temporary cantonment was established at Pagosa Springs, which has since been enlarged and established as a permanent post under the name of Fort Lewis, and I was ordered to survey the boundaries of a military reservation for this post in December, 1878.

This work was done between December 10 and 17, in the midst of very cold weather, the thermometer dropping to 23° below zero. A reservation 6 miles square was laid off, which, excluding therefrom the township reservation of 1 mile square made by the President May 20, 1877, contains 35 square miles of land, which will some day be very valuable, and which, in connection with the new scheme relative to the consolidation of the Ute Indian tribes in this vicinity on a new and very much smaller reservation, will make an important military location. The very fact of a military post established at this point has brought a small population of 500 to the new town, where six months before was found only one house.

Under special orders of the department commander, I left Fort Leavenworth on April 10, and inspected the condition of the Alamosa road as far as finished, and then went to Pagosa Springs and was engaged till the end of the fiscal year in making a detailed survey of the interior of the military reservation at Fort Lewis, and in preparing estimates and making examinations relative to the building of the new post. The survey has been completed, and a map is now being prepared showing the details, contour lines, &c., of this reservation. Work having begun on the Alamosa and Pagosa Springs' wagon-road, my station has been changed to Fort Lewis during its continuance. During the summer and fall, and probably with the winter, I expect to be employed on these works.

There being no funds available for surveys, there has been no surveys conducted under my direction this year other than those mentioned. Lieuts. J. B. Lockwood and C. H. Heyl, of the Twenty-third Infantry, have been engaged under orders from the department and post commanders in making surveys and measurements of the roads leading from Wichita and Fort Supply to the new cantonment on North Fork of Red River, in the Indian Territory, and plats of these surveys have reached my office. The usual number of maps have been distributed, but there has been very little office work done, owing to lack of material and my absence on personal duty from my station all but 3½ months of the year.

I submit herewith, in connection with my last year's report, a very valuable chemical report made by Dr. Charles Smart, United States Army, on the specimens of deposits and water, submitted by Lieutenant McCauley and collected by him at Pagosa Springs.

This report is of special value, as covering some peculiar conditions of animal and vegetable life at these springs; which, remarkable from so many points of view, are more likely to come to the public notice as their peculiarities are known.

Very respectfully, your obedient servant,

E. H. RUFFNER,
*First Lieutenant of Engineers.*

The CHIEF OF ENGINEERS, U. S. A.

## R R I.

# CHEMICAL REPORT ON THE PAGOSA SPRINGS OF COLORADO, BY CHARLES SMART, ASSISTANT SURGEON, U. S. A.

### LETTER OF TRANSMITTAL FROM LIEUTENANT M'CAULEY.

FORT FRED STEELE, WYO.,
*June* 19, 1879.

SIR: I have the honor to transmit herewith "*Chemical Report on the Pagosa Springs of Colorado,*" just received from Dr. Charles Smart, assistant surgeon United States Army, the inspector, &c., of the National Board of Health, lately stationed at Fort Preble, Maine.

In June, 1877, while your assistant, having been sent from department headquarters into the field in charge of the "reconnaissance of the San Juan country of Colorado," the results of which are contained in your annual report for 1878, lately issued from the office of the Chief of Engineers, I collected while in camp at Pagosa Springs, Colorado, samples of the waters for analysis.

Dr. Smart, who had kindly promised to make the investigations gratis, being at that time changing station, the waters were shipped to a chemist in the office of the Surgeon-General at Washington, by whom, owing to a press of work on hand, they were overlooked. On account of the resulting deposition no report could be obtained.

The following year another effort was made to obtain the necessary water from the springs, which during the summer was prevented by the duties incident to the work of the Ute Indian Commission. The latter concluded, the journey from Fort Garland over the mountain ranges to Pagosa was undertaken in winter, occupying five weeks, including the time at Fort Garland, when engaged upon the report.

The report upon the springs, made agreeably to telegraphic instructions from the commanding officer, district of New Mexico, was duly forwarded to Santa Fé, N. Mex., thence being sent to the commanding general, Department of the Missouri, by whom it was forwarded to the Secretary of War, appearing as Senate Document No. 65, Forty-fifth Congress, third session, March, 1879.

The various waters obtained for qualitative and quantitative analyses—thirty quarts in all—securely bottled and very carefully packed for mountain travel, were supplemented by a large and complete collection of deposits from the springs, and were shipped from Camp Lewis, Pagosa Springs, in December, via Fort Garland, Colo., reaching department headquarters at Fort Leavenworth, Kansas, late in January, 1879. Having been exposed in transit to low temperatures, as great as —20° or —30° F., 90 per cent. of the samples were ruined by freezing and breakage. The three quart bottles remaining, repacked and reshipped, with the collection of deposits, reached Dr. Smart at Fort Preble, Maine, in March last, the report herewith transmitted to you being the results of his investigation thereon.

Although not now on duty in your office, I beg leave to forward it at once, requesting that, if possible, it may be printed with your annual report for 1879. The result of careful and extended research, it will be found an exceedingly interesting and valuable document.

I am, sir, very respectfully, your obedient servant,

C. A H. MCCAULEY,
*First Lieut. Third Cavalry, late Assistant to Chief Engineer Department Mo.*

First Lieut. E. H. RUFFNER,
*Chief Engineer, Department of Missouri.*

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### LETTER OF TRANSMITTAL FROM DR. CHARLES SMART.

FORT PREBLE, PORTLAND, ME., *April* 10, 1879.

SIR: I have the honor to forward to you the results of an investigation into the inorganic constituents of certain waters from the Pagosa Springs of Colorado.

The waters were contained in three bottles, securely corked and in good condition, each containing about 17 ounces, and marked, respectively, "spring No. 1," "spring No. 10," and "spring No. 17."

The loss of 90 per cent. of the samples from freezing and consequent breakage during transportation was unfortunate, as the water was supplemented by a fine collection of deposits from the springs, which, with the original quantity of the samples, would have left nothing to be desired to complete an accurate analysis. As it is, the water was in too limited a quantity to admit of satisfactory conclusions, and the analysis of each would have been comparatively valueless but for the testimony which each bears to the accuracy of the other.

Operations on minute quantities of matter, besides requiring greater care than is usually given to technical analysis, have their slight manipulative errors greatly magnified when recorded as per gallon. Qualitative examination showed in each the same constituents—lime, magnesia, soda and potash, chlorine, carbonic and sulphuric acids, and traces of iron and alumina—the last only in such proportions as are found in ordinary potable waters.

Fifty cubic centimeters were used in the determination of the chlorine by volumetric, silver solution; the same quantity was employed for the carbonic acid by normal acid and alkaline solutions; and another such volume for sulphuric acid by precipitation; and the balance, one hundred and fifty cubic centimeters, were evaporated for the total solids, the lime of which and the magnesia were separated and weighed; while another volume of 150 cubic centimeters was employed in determining the relative quantities of the alkalies. About one-fourth of the sample was thus reserved for a repetition of an experiment in which accident might interfere to render the result doubtful.

The following represents the constitution of the springs as accurately as the amount of the samples will permit:

| | Spring No. 1. | Spring No. 10. | Spring No. 17. |
|---|---|---|---|
| Sulphate of soda, in grains per gallon | 139.0 | 117.0 | 101.0 |
| Potassium, chloride | 19.0 | 13.8 | 13.6 |
| Lime, carbonate | 41.0 | 43.4 | 30.4 |
| Magnesia, carbonate | 2.5 | 2.1 | 3.4 |
| Lime, sulphate | 11.4 | 10.2 | 10.0 |
| Total in grains per gallon | 212.9 | 186.5 | 158.4 |

These results have their error on the side of excess, the totals by evaporation being 204, 173, and 141 grains per gallon, in the No. 1, No. 10, and No. 17 springs, respectively. Most of the deposits from these springs are mixtures of lime sulphate with carbonates of lime and magnesia, the lime sulphate greatly preponderating. One sample, marked as from the bottom of spring No. 1, consists almost purely of sulphate of lime.

Among the specimens marked as collected near this spring (No. 1) was a fragment of moss, which had been thickly incrusted with the more soluble salts of the water. This was employed to determine the relative proportions of the alkalies, as the evidence from the water sample was not so trustworthy as desirable. The result demonstrated the presence of potassium in quantity to combine with the chlorine found, leaving the sodium entirely as sulphate.

In this specimen a show of lithium was obtained by precipitation, so that its existence is probable in the water also.

These springs may be regarded as virtually the same water; No. 1, for instance, being simply diluted by the influx of tributaries of less saline character to produce the waters of Nos. 10 and 17. The springs are presumably laxative and slightly antacid.

I have the honor to be, very respectfully, your obedient servant,

CHARLES SMART,
*Captain and Assistant Surgeon, U. S. A.*

Lieut. C. A. H. McCAULEY,
*Third United States Cavalry.*

## REPORT.

The water and samples of deposits, the analyses of which form the basis of the following report, were collected in December, 1878, by Lieutenant McCauley, Third United States Cavalry, assistant engineer, Department Missouri, during his explorations in and around the springs. Although a fair quantity of water for analytical purposes was bottled from each of the notable springs, the low temperature to which it was exposed on its way from Colorado to Fort Leavenworth caused freezing, with consequent breakage and loss, so that there were forwarded to the writer only three bottles, each containing about 17 ounces, and marked, respectively, Spring No. 1, Spring No. 10, and Spring No. 17. The loss was unfortunate, as the waters were supplemented by a large collection of deposits from the springs, which, with the quantity originally bottled, would have left nothing to be desired to complete an accurate analysis.

As it was, the water samples were too limited in quantity to admit of satisfactory conclusions in the individual case, and the analysis of each would have been comparatively valueless but for the testimony which each bore to the accuracy of the others. Operations on minute quantities of matter, besides requiring greater care than is usually given to technical analyses, have their slight manipulative errors greatly magnified when recorded as per gallon.

Qualitative examination showed in each the same constituents, calcium, magnesium, sodium, potassium, chlorine, carbonic, and sulphuric acids, with traces of iron and alumina, the last only in such proportions as are found in ordinary potable waters. Fifty cubic centimeters were used in the determination of the chlorine by volumetric silver solution; the same quantity was employed for the carbonic acid by normal acid and alkaline solutions; and another such volume for sulphuric acid by precipitation and the balance. One hundred and fifty cubic centimeters were evaporated for the total solids, the calcium of which and the magnesium were separated and weighed; while another volume of 150 cubic centimeters was employed in determining the relative quantities of the alkalies. About one-fourth of the sample was thus reserved for a repetition of any experiment in which accident might interfere and give uncertainty to the result.

The following represents the constitution of the springs as accurately as the amount of the sample of each will permit:

| | Spring No. 1. | Spring No. 10. | Spring No. 17. |
|---|---|---|---|
| Sodium sulphate | 1.986 | 1.671 | 1.443 |
| Calcium carbonate | .586 | .620 | .434 |
| Calcium sulphate | .163 | .146 | .143 |
| Magnesium carbonate | .036 | .030 | .049 |
| Potassium chloride | .271 | .197 | .194 |
| Total in grains per liter | 3.042 | 2.664 | 2.263 |

These results have their error on the side of excess, the totals by evaporation being 2.914, 2.471, and 2.014 grains per liter in the No. 1, 10, and 17 springs, respectively.

Among the specimens marked as collected near spring No. 1 was a fragment of moss which had become thickly incrusted with the more soluble salts of the water. This was employed to determine the relative proportions of the alkalies, as the evidence from the water sample was not satisfactory. The result demonstrated the presence of potassium in quantity to combine with the chlorine found. In this specimen a show of lithium was obtained by precipitation, so that its existence is probable in the water also.

On account of the meager supply of water from the three springs represented, and the absence of any information concerning their locality and relations, the writer's interest in them ceased.

They were regarded as virtually the same water; No. 1, for instance, being simply diluted by the influx of the tributaries of less saline character to produce the waters of Nos. 10 and 17. Some of the packets of deposits, marked as from Nos. 1 and 17, were opened, and calcium sulphate and carbonate having been recognized as their principal constituents, the large assortment of specimens were set aside unopened; those from the springs examined as unnecessary, since sulphate and carbonate, with an overlying water containing these salts, presented nothing to excite curiosity, and those from the other springs as possessing no interest in the absence of the water from which they were deposited. The receipt at this time of Mr. McCauley's report on the springs awoke an interest in the specimens in the writer's possession, by making known the relationship of their mother waters, so far as this could be discovered by inspection. Nos. 1 and 10 springs were shown to be the reservoir and outlet of the same water, an underground channel connecting the two. During its progress from the one to the other the water lost temperature from 141° to 127° Fahr., by evaporation, conduction through the rocks, and inflow of surface-water by percolation, to which last is to be attributed the reduction in the saline constituents from 3.042 to 2.664 grams per liter.

Spring No. 17 was shown to be separated from No. 1 by a greater distance than No. 10, thus permitting a greater reduction in temperature and a greater dilution, the one falling to 110° and the other to 2.263 grams per liter. Moreover, No. 17 is an outlying spring, without visible communication with either 1 or 10; yet, as its waters were proved by the analyses to be similar in constitution, it was fair to conclude that all the other springs which find an exit on the same calcareous mound or plain, and which are nearer to No. 1 than is No. 17, must be derived from the same source, and that the deposits from any of the springs might be taken as illustrative of all. The singular character of the deposits described by Mr. McCauley were unaccountable in view of the constitution of the waters. Sulphur, which figures so largely in his description, had been present only in the water of spring No. 1, and even in this case the sulphuretted odor was so faint as to be set down as accidental and owing to the decomposition of sulphates in the presence of organic matter. The earliest opportunity was therefore taken of examining these specimens, and with the results which follow. But before detailing them, a reference is needful to an analysis given in Mr. McCauley's report as published in a popular work on Colorado; the authority therefor not being stated. This analysis, I infer from an article on the Mineral Springs of Colorado, by Dr. T. G. Horn, in the second annual report of the State board of health, must be that of spring No. 1, which was made in connection with Lieutenant Wheeler's survey, the result, for the popular convenience, having been rendered into grains per wine gallon. Dr. Horn quotes from Lieutenant Wheeler's report the constitution of four of the springs, which in grams per liter give the following results:

| Constituents. | No. 1. | No. 2. | No. 3. | No. 4. |
|---|---|---|---|---|
| Sodium carbonate | .047 | .033 | ........ | ........ |
| Lithium carbonate | .007 | Trace. | Trace. | Trace. |
| Calcium carbonate | .590 | .595 | .545 | .56 |
| Magnesium carbonate | .048 | .039 | .037 | .03 |
| Potassium sulphate | .071 | .070 | .066 | .07 |
| Sodium sulphate | 2.217 | 2.202 | 2.239 | 2.24 |
| Sodium chloride | .292 | .294 | .312 | .29 |
| Silicic acid | .057 | .052 | .055 | [illegible] |
| Organic matter | Trace. | Trace. | Trace. | Trace. |
| Total solid constituents | 3.329 | 3.285 | 3.254 | 3.27 |

Gases, carbonic acid, and hydrogen sulphide. These may probably give a more accurate representation of the totals in the main spring and its immediate neighbors than is afforded by the recorded results of analytical operations on the small quantity furnished to the writer. But exception must be taken to the presence of sodium carbonate in the main spring, and the consequent absence of calcium sulphate in its waters. At the time when special attention was directed to this point by the receipt of Mr. McCauley's report, a small portion of the water of the main spring remained on hand, having been reserved in case of accident. This was made use of to determine the point at issue. It was evaporated to dryness; its soluble salts were dissolved in a few drops of water, which, when filtered, gave no alkaline reaction nor any liberation of carbonic acid when treated with acid; thus excluding the presence of an alkaline carbonate, and showing no chemical objection in the way of the existence of calcium sulphate in the original water. The calcareous film in the capsule was then washed with water until the washings showed no trace of chlorine, when it was conceived that all the sodium sulphate must have been removed. Subsequent digestion in water gave from the film a solution which showed the presence of sulphuric acid and yielded a precipitate with ammonium carbonate, proving the presence in the original water of calcium as sulphate.

Moreover, as will be seen hereafter in discussing the crystallizations from the springs, calcium sulphate in solution is a necessary factor in their formation. A *résumé* of the situation and surroundings of this group of hot springs, gathered from Mr. McCauley's interesting report, is needful to show, in connection with the analyzed deposits, the identity of the waters. They are excavated in a calcareous rock which forms the surface-layer of a part of the San Juan River Valley; the river running first westward, then southward, and then inclining a little eastward in its southerly course, from a horseshoe bend, in the concavity of which is the area in which the springs are situated. The open end of the horseshoe is bounded by rolling hills. At a point about 150 yards from the prong of the horseshoe, 300 yards from its concavity, and about 400 yards from the short or refused southern prong, is the site of the Great Hot Spring, the highest part of the area. From this the surface of the Cretaceous rock declines, but so gently that the area is more of a plain than a decline towards the river, where it ends in a water-cut face with a height of from 4 to 15 feet above the level of the running water.

The main spring, or No. 1, is oval in outline, 69 by 45 feet, and of unknown depth. The rock at its margin is slightly tilted up, so as to give the basin a crater-like rim. The water level is 5 feet below the rim, and there is no surface outflow. Bubbles of gas, mainly hydrogen monosulphide, arise and break all over the surface; but the greatest disengagement of gas is localized near the center, whence a discolored scum is wafted to the sides, where it sinks, settling at the unknown bottom or on interposed ledges of a more or less crystalline structure, and develops darker and beautiful hues, of which green is the prevailing tint. The temperature of the spring is 141° Fahr. Underground channels carry the water from this basin northward to the San Juan River, the outflow appearing on the water-cut section of the Cretaceous rock, about 4 feet below its surface and 6 feet above the present level of the river. The principal points of outflow constitute springs Nos. 9 and 10, both of which have the same temperature, 127° Fahr. On the line of direction of these channels are several holes, varying in diameter from 1 to 5 feet, which have been set down as springs Nos. 2, 3, 4, 5, and 6. These have temperatures intermediate between those of the termini of the channels, and their deposits are in general terms similar to those of No. 1.

Spring No. 7 lies on the same line, but has a less free communication with the underlying current, as its temperature is reduced to 101°. Its deposits differ from those of the others, being uniformly of a reddish tint.

Spring No. 8, near by, is now filled up by deposits similar to those in No. 7.

About 100 yards south of the main spring are a series of openings, marked as springs Nos. 11, 12, 13, 14, and 15. These have an overflow, forming little rills, which unite, and, running southward, are lost in a swamp which lies between the great basin and the river on this side. Their temperature, No. 12 excepted, is but a few degrees below that of the main spring, and the deposits in the channels of the running water are at first similar to those of spring No. 1; but farther on, and especially after their junction with the runlet from No. 12, the temperature of which is 102° Fahr., the character of the deposits becomes changed.

In the swamp are springs Nos. 18 and 19, small holes, with an outflow, in the channel of which is a black deposit. Temperature, 99° Fahr.

Nos. 16 and 17 are between the main springs and the river on the west, their temperatures 107° and 110° Fahr., and their deposits presenting grayish and reddish tints. The calcareous rock is not confined to the Hot Spring side of the river. It passes under the gravelly bed of the stream, and appears on the right bank, with a clean-cut face slightly higher than that on the opposite side. Its surface affords a site for the military fort of Camp Lewis; but generally, on the right bank, its existence as a surface stratum is narrowed to a few hundred feet bordering the river. About half a mile below the hot springs, but on this, the right bank, are three cold springs, closely grouped together on a slight mound or elevation similar to that existing around the basin of the main spring. One of these is 12 feet in diameter, the others being somewhat larger. There is in these but little water movement, and no outflow save by percolation through the porous rock. The bottom here furnishes only a dark-colored mud. Half a mile farther down stream, in the banks of the Ojo Frio Creek, and even in its bed, are cold sulphureted springs, much more highly charged with this element than those last mentioned, but no samples were collected from them. These are on the left or hot spring side of the San Juan River. Understanding thus the position of the springs, the deposits may now be presented.

(*a.*) "*From side of cliff near river bank, 300 yards west of the main spring.*"

A light ash-gray block of mineral matter, imbedding some petrified grass culms. It consists of 89 per cent. of calcium carbonate; calcium sulphate, and especially silica, making up the rest.

(*b.*) "*Stalagmite from spring No.* 1."

An irregularly-shaped mass, granular and friable, breaking with a glistening metalloid fracture. It is grayish in color, with tinge of yellow, and has small yellow flakes on one surface and whitish grains of efflorescence on the other. The flakes are pure sulphur; the white granules are sodium sulphate with free sulphuric acid. There are no sulphides present.

| | |
|---|---|
| Sulphur | .968 |
| Silica | .019 |
| Calcium sulphate | .007 |
| Acid sodium sulphate | .006 |
| | 1.000 |

(*c.*) "*Spring No.* 1, *sides.*"

In general aspect similar to the last, but faced in part with a whitish reticulation of calcium sulphate. This, on analysis, gave:

| | |
|---|---|
| Calcium sulphate | .720 |
| Sulphur | .216 |
| Silica | .037 |
| Sodium sulphate | .020 |
| | .993 |

(*d.*) "*Spring No.* 1."

A cancellated mass, heavier than those already examined, opaque, creamy-white, and with a crystalline luster. This gave:

| | |
|---|---|
| Calcium sulphate | .859 |
| Sodium sulphate | .001 |
| Silica | .019 |
| Sulphur | .095 |
| | .974 |

Ten grams of this specimen were operated on for the sodium, and in the extract the presence of lithium was demonstrated.

*(e.)* "*Spring No.* 1."

Some mineral crusts, contorted and irregular in shape, but generally about half an inch thick, consisting of several layers distinct in character—an ash-gray granular basement with a lively green streak between it and an overlying dense white crystalline layer, which last is faced with a white efflorescence. A taint only of sulphur is discoverable in this specimen. The gray is granular carbonate, the white crystalline calcium sulphate, and the efflorescence sodium sulphate. The green layer consists of granular cells, the cellular structure being made out with difficulty.

The sample was boiled with hydrochloric acid to rid it of mineral matter. Many minute siliceous particles, elongated and rounded at the ends, are imbedded in the organized tissue; and a number of spores, each spherical cell $\frac{1}{1000}$ of an inch in diameter, being densely filled with brown granules, are seen on the field. Frequently two such cells are inclosed in a common envelope, forming an elongated double spore, the mother cell of which is distinctly seen as it passes across the sulcus between its spheroidal inclosures. In some, rupture of the parent cell under pressure of the thin glass can be observed, with the spores in the act of escaping from its folds.

*(f.)* "*Spring No.* 1, *pulpy, liver-like matter at the bottom.*"

This specimen is a portion of a tablet about half an inch thick, dark-brown in color, with a dull-greenish admixture. It consists of a series of horizontal laminæ, roughened with microscopic siliceous particles. In fact, on a superficial examination, it looks as if a number of leaves, more or less discolored with mud, had been compressed and dried to form the cake. The under surface is rough, dusted over with fine granules of sulphur, and pitted and pin-holed as if by gas bubbles which had been confined by the overlying mass. The upper surface is smooth and unbroken. Twenty-six per cent. is organic matter. The mineral matter consists chiefly of the elongated siliceous particles seen in *(e)*, together with calcium sulphate, sodium from the water, and a notable proportion of iron and aluminium, no doubt from the ash of the organic matter.

Under the microscope, the sample, after soaking in water for twenty-four hours, shows as a finely granular, greenish membrane. This homogeneity of structure is best seen in the surface layer, which is less studded with silica. Portions from the deeper layers show much mineral matter and many spores, such as were seen in *(e)*. Soaking in caustic alkali does not alter the microscopic appearances.

Hydrochloric acid, while it fails to clear the field of the mineral accretions, shows the spores more distinctly. The greenish membrane is such a field as would be given by the drying under pressure of a layer of fungus cells.

*(g.) Spring No.* 1. "*From bottom.*"

This consists of a thin plate, showing three layers of matter. That which constitutes the under surface is a delicate film of minute sulphur granules, pitted and pin-holed as in the last specimen. The middle layer, one line in thickness, consists of the dark-brownish folia of *(f)*; while covering the surface is a hard, irregular incrustation varying in color from white through shades of rose to scarlet. The last is mineral matter imbedding membranous shreds, which gives it its color. The membrane is homogeneous and very delicate; no treatment resolved it into its structural elements. The mineral is 99 per cent. calcium carbonate, with traces of calcium sulphate, magnesium, and the organic matter. The purity of the carbonate and its relation to the rose-red membrane are suggestive of a vital connection between them.

*(h.)* "*From bottom of spring No.* 1."

A foliated mass like *(f)*, but with less of brown and more of green in its coloring, with some grains of sulphur adhering to its under surface, and some nodules of calcium carbonate inlaid on its upper, apparently by the same agency as in the last specimen.

*(i.)* "*From bottom deposits of spring No.* 1."

Similar to the last, but with many more pits on its under surface from confined gas bubbles.

*(j.)* "*Five specimens from spring No.* 2."

These are all crystalline forms of calcium sulphate, three having large interspicular spaces, while the two other specimens are more compact. One has a vein of lively green running through it, which, on microscopical examination, presents the characters of the organic matter occurring in mass foliaceous specimens.

*(k.)* "*Spring No.* 5."

A block 3 inches thick, consisting of two layers, the superficial, constituting two-thirds of the thickness, being cancellated calcium sulphate, and the other dark colored calcium carbonate, with traces of iron, aluminum, and silicates.

(*l.*) "*Spring No.* 5."

A large mass, 10 inches long, 4 inches deep, and 2 inches thick, consisting on its outer or earthward surface of calcium carbonate, ash-gray in color, mottled with dark shades, but principally of calcium sulphate, solid in its deeper layers and specular towards its superficies, where it has become white and opaque, partly from loss of water and in part from sodium efflorescence. A greenish tinge, faint in some of its streaks but rich and vivid in others, permeates the interspicular passages. The coloration is caused by the presence of a vegetable fungus, minute rounded cells, like those of the yeast-plant, and of the same size. As the green tinge is frequently continuous with or lost in the darker stains of the deeper layer, it is probable that the carbonaceous remains of previous generations of the fungus contribute to the darkening.

In view of the similarity in the appearance of these green stains to those described as occurring in the crusts of (*e*), and the similarity in the microscopic appearances of the latter to those of the "pulpy, liver-like matter" of the dried specimens (*f*, *g*, *h*, and *i*), it is not unlikely that this fungus forms the essential of these various deposits.

(*m.*) "*Spring No. 7.*"

A cake eight inches square by one inch thick of porous material having a rose-red color. The mineral matter is arranged in small branching modulated columns, none larger than one line in diameter and the majority much smaller. Their direction is upward from the attached or earthy to the free surface, but none run through the thickness of the cake unconnected by branches, transverse bars or lamella with other columns. The intercolumnar spaces are narrow, being usually no larger than the diameter of the columns, and their general direction is upward through the thickness of the mass. A perpendicular section shows a reticulated bony framework with the meshes chiefly longitudinal. A horizontal section gives a series of roundish interstices separated by bony columns and lamella. All the interstitial cavities are lined with a delicate reddish membrane, which, when in single fold, gives a faint color to the white underlying mineral, but where the membrane has adhered in several thicknesses in drying the color is correspondingly deeper. On the surface the cake is a layer of organic material, scaly and brownish, light and pulverulent, which adheres to the reddish membrane below.

When this layer is cautiously picked off the surface, apertures leading into the intercolumnar space are exposed.

The following is the chemical constitution of the mass:

| | |
|---|---|
| Calcium carbonate | .964 |
| Organic matter | .022 |
| Silica | .004 |
| Sodium, salts, &c | .010 |
| | 1.000 |

The specimen is hard and comparatively difficult to pulverize.

The red membrane is granular, and the carbonate is deposited on its surface in roundish or oblong granules.

No reagents develop the structural elements of the membrane.

The dried organic *débris* on the surface of the specimen gives no information under the microscope. A large number of diatoms are entangled in it. The general appearance of this specimen, the relation which its organic bears to the inorganic portion, and the purity of the carbonate would seem to indicate that there is some coral secreting polyp under examination rather than a deposition or crystallization by inorganic forces from the waters of the spring.

The investigation of this specimen throws more light on the superficial incrustation seen in (*g*).

(*n.*) "*Spring No. 7.*"

Ten specimens smaller in size but similar in other respects to the last.

In one of the pieces a plate of calcium carbonate surmounts the columnar growth. It is dense and hard but thin as a sheet of writing paper. On its surface are built up alternate layers of columnar and plate work, half a dozen such layers in the thickness of half an inch, suggesting that the polyp or secreting organism, nullipore, perhaps, on reaching the surface of the water by upward columnar growth, deposited its calcareous secretions in the form of a plate level with the surface of the water and extended by circumferential accretions; a rise in the water level submerging this plate gave opportunity for an upward columnar development when the water was again reached and another plate formed.

(*o.*) "*Spring No.* 10, *one of the outlets of spring No.* 1."

A fine satiny powder of pale yellow color, looking, but for its color, like sulphate of quinine.

This is pure sulphur, deposited in fine silky needles and fibers. There is no approach in this specimen to octahedral crystallization.

*(p.) "From the junction of waters of springs Nos.* 11 *and* 13; *the top of this specimen was dark green, with several bright crimson spots when taken from the water, soft and pulpy."*

This specimen is broken into fragments, none larger than a pea, and consists of carbonate and sulphate deposited around various extraneous matters as nuclei, chiefly minute fragments of recent woody tissue. One tubular piece, about half an inch long and half a line in diameter at its open and wider end, is, from its segmentation, supposed to be the incrusted abdomen of an insect. There are also present some dark green and brown flakes spotted with crimson. These flakes, although apparently like the organic foliations already described, are of a totally different structure. They consist of minute filaments with an infinity of bacteroid rods floating among them as their *débris*. The red spots are also filamentous webs. There is here a low form of vegetable life, but much higher in the scale than the cellular fungus encountered heretofore.

*(q.) "From junction of springs Nos.* 11 *and* 13; *from deposits at bottom stalagmites of pulpy matter arise, and the top at surface of water spreads into thin sheets, as per sample."*

This is a strong lamella of calcium carbonate, thin as a sheet of writing paper, circular in outline, and about two and a half inches in diameter. Its surface and margins are marked with reddish membranous shreds similar to those seen in *m* and *n*. It no doubt represents the deposition of the calcareous secretion when the zoöphyte reaches the surface of the water.

*(r.) "From bottom of spring No.* 17."

A large mass of semi-translucent grayish crystals which in some parts of their surface have lost water and become opaque and friable.

| | |
|---|---|
| Anhydrous calcium sulphate | .810 |
| Water | .190 |
| | 1.000 |

*(s.) "Deposit at spring No.* 18 *and beyond for* 120 *feet."*

This is a dry dark-brown or blackish cake, thin, flat, and apparently bent on itself, so that what would have constituted one end of the sample in its natural condition is now doubled up to form the under surface. The upper surface is smooth and unbroken; the lower is made up of a number of their adhering bands, one or two lines broad, but their mode of connection with the more compact layer above cannot be made out, on account of the brittleness of the specimen.

Portions were soaked for twenty-four hours in water, hydrochloric acid, and caustic alkali, respectively, and were examined under the microscope, when the bands were found to consist of brownish tubules. The mass of the specimen could be recognized as including three layers, the lowest being dull green in color, the central reddish, and the superficial bluish green. The first is obscurely cellular and filamentous in the water-soaked specimen; and while the acid shows the filaments clearly, with many bacteroid rods among them as their *débris*, the alkali clears up the interlying cellular structure. The central or reddish stratum is granular and undefined by the acid, but the potash resolves it into tiers of oblong and slightly-curved spores with some minute tubules delicately and closely ringed. The bluish-green stratum consists of minute distinctly double outlined filaments or tubules. A vast number of diatoms are entangled in these tissues.

*(t.) " Mud from the cold springs."*

A dry, dark-colored, irregularly-shaped, clay-like mass, with many small fragments of recent vegetable matter embedded in it. No sulphides are present. The following is its constitution:

| | |
|---|---|
| Calcium carbonate | .546 |
| Insoluble clay and sand | .250 |
| Organic matter | .120 |
| Moisture | .058 |
| Calcium sulphate | .010 |
| Magnesium carbonate | .008 |
| Potassium sulphate and traces of chloride | .004 |
| Sulphur | .003 |
| Iron, &c | .001 |
| | 1.000 |

In reviewing these specimens, it is found that they originate from the water of the springs either in deposition, in crystallization, or through the instrumentality of organic life.

Sulphur is the only deposit. It is fruitless in the absence of data to speculate on the subterranean reactions which result in the impregnation of the uprising water with calcium and bicarbonate and sulphate, sodium sulphate, and hydrogen monosulphide; but when the current reaches an exit in its rocky channel where the only pressure to be overcome is that of the superincumbent water and atmosphere, the changes which take place can be appreciated. The sulphuretted gas escapes, and escapes the more readily owing to the high temperature of its solvent. It rises in bubbles to the surface, but as the effervescence is limited to a few feet near the center of spring No. 1, the fissure of inflow in the bottom of the rocky basin is no doubt correspondingly limited. Most of the gas escapes into the atmosphere, to be diffused and decomposed by its oxygen; but bubbles form on the surface, which are wafted to the sides, and in their progress are first coated with a film of solid matter—deposited sulphur from the action of the air on the contained gas—and then so heavily loaded by coalescence and aggregation that they sink and form a sulphur mass, such as is seen in specimen *(b)*, or, having been swept out of the main downward current of deposited sulphur, they settle on and become embedded in the crystallizations from the water as seen in *(c)* and *(d)*. On the surface of the sulphur a cellular fungus is developed, which, in the recent state, is soft and pulpy in mass, but molecular in element, for, on being stirred, it becomes diffused in the water, and subsequently settles. This organism, with its bright green hues, masks the real nature of the underlying deposit; the greater portion of the sulphur is necessarily deposited near the point of issue of the water in the great basin. But as the outflow therefrom courses through its underground channels in the calcareous rock, the gradually-decomposing gas, while barely tainting the crystallizations, throws down sulphur in places favorable for its subsidence, as is seen in the crystalline needles and fibers from the outlet marked as Spring No. 10.

From the deposits it would appear that there is no communication with subterranean reservoirs other than in the bottom of the main spring, and that consequently the other springs are dependent upon it for their water supply. Some of the constituents of the deposits are accidental, as the sodium sulphate which exists in all of them in small quantity, and is owing to the evaporation from the specimen of adhering water which contained it. Again, in the specimen (*e*) the incrusted lime salts are undoubtedly owing not to crystallization but to soakage and subsequent evaporation. The free acid in (*b*) is due to oxidation changes in the specimen occurring since its removal from the water.

While sulphur is the only deposit and is concentrated in the neighborhood of the primary subterranean outlet, calcium sulphate is the only crystallization, and is distributed along the whole course of the waters, for it is found in as perfect crystals in spring No. 17 as in No. 1. Its best specimens are from the holes or basins which afford favorable conditions for its growth. This crystalline lining of the water reservoirs and courses is in none of the specimens more than two inches thick, and is fused on its outer or earthward surface with calcium carbonate, showing either that it is very slow in its formation or that the springs and channels are of recent date. The latter supposition is excluded by facts which will be mentioned hereafter. But as the water contains such a small quantity of calcium sulphate, one part in six thousand, while the solubility of the salt is put as high as one to a few hundreds, the occurrence of selenitic crystallizations from such a water becomes a matter for investigation. It seemed probable that some of the other constituents exercised a precipitating influence, yet certainly not the sodium salt, as it is well known to increase the solubility of calcium sulphate. To throw some light on the subject, sodium sulphate was added to a solution of calcium bicarbonate and to another of calcium sulphate, but in neither with any apparent result. A mixed solution of the two calcium salts was then treated with pure sodium sulphate, and at the end of twelve hours crystallization was seen taking place at the bottom of the containing vessel, and depending from the surface of the liquid adhering probably to floating fibers from the paper through which the solution had been filtered prior to use. At the end of twenty-four hours the crystals, having increased in size and number, were removed. They showed under the microscope as transparent rhombic plates and oblique elongated prisms, such as by aggregation constitute the mass of the selenitic crystallizations from the springs. The transparent crystals were difficultly soluble in water acidulated with hydrochloric acid, even when boiled therewith. On examination the calcium of the original solution was now found to be deficient in the mother-liquor, and markedly present in the solution of the crystals, in which sulphuric acid was strongly indicated. Calcium sulphate was therefore inferred to have crystallized out of a solution containing in addition to itself calcium bicarbonate and sodium sulphate. Having approximated the conditions under which the crystallization took place, a further experiment was made to determine at the expense of which salt the calcium was thrown out. Distilled water acidulated with sulphuric acid was digested with an excess of calcium carbonate. Calcium sulphate was formed under circumstances favorable for its solution, and bicarbonate was dissolved by the permeation of the liquid with the escaping gas.

The solution was filtered and 90 cubic centimeters were found to contain calcium, which when thrown down as carbonate weighed 294 grams, and which when in solution existed in the proportion of .050 grams carbonate and 333 grams sulphate. Ninety-nine cubic centimeters of this solution were placed in each of four flasks, *a*, *b*, *c*, and *d*, and to each was added 10 cubic centimeters of a sodium sulphate solution, containing, for *a*, 300 grains; *b*, 900 grains; *c*, 1,800 grains; *d*, 3,600 grains; so that each 100 cubic centimeters of water contained the same quantity of calcium as carbonate and sulphate, but differing quantities of sodium as sulphate. The flasks were corked to prevent evaporation and were set aside. Crystalline precipitation took place in all, slowly, as in the preliminary experiments. At the end of three days the calcium remaining in solution was estimated in *a*, *b*, and *d*. One-half of *c* was devoted to this estimation, while the other half was evaporated and its concentrated solution found to be free from alkaline carbonate. The calcareous film, however, contained 25 grams of carbonate as it existed before treatment with the sodium sulphate. The calcium carbonate was therefore inferred to have been similarly acted on in the other flasks, giving as cause for the precipitation the presence of bicarbonate in the solution and not the formation of sodium carbonate by reaction between the salts. (*a*) gave .174 grams calcium carbonate, or calcium sufficient to furnish the solution with its .050 grams of carbonate and with .169 grams of sulphate, giving .164 grams as the quantity crystallized; (*b*) gave .101 grams of carbonate, or the equivalent of .050 grams carbonate and .070 grams sulphate, .263 grams of the latter salt having crystallized; (*c*) gave the .050 grams carbonate, with .071 sulphate, .262 grams of the sulphate having been precipitated; (*d*) gave the carbonate with .098 grams of the sulphate, indicating a precipitation of .235 grams. The maximum of effect was obtained in (*b*), an excess of sodium sulphate exercising a solvent action on the crystals.

The deposits which result from the development of organic life differ in different parts of the water-course.

In the main spring and its direct effluents is found one of the lowest forms of vegetation, a microscopic fungus developing into pulpy layers, several inches in thickness, in situations where there is the necessary quiet for favoring its growth, as in (*f*), (*g*), (*h*), and (*i*), and permeating the crystalline lining of the basins with its lively green stains, as in (*e*), (*j*), and (*l*). In the main spring there also appears, as in (*g*), a polypoid secretion of calcium carbonate, which meets with more congenial conditions in spring No. 7, (*m*) and (*n*), along the channel formed by the junction of 11 and 13 (*q*). It is probable that this growth is more active as an agent for obliterating existing channels than the sulphate crystallization. Spring No. 8, which was open in August, 1877, having been found closed in December, 1878, "a dampness on the surface and the distinctive red character" alone marking the site of the former cavity. There are no phosphates in this coraloid carbonate. In the channel of junction of 11 and 13 is found a low form of water plant, coating the surface of the mineral deposit with green and crimson, as the lichen incrusts the rock; and in the channel of 18 and 19 is a higher grade of vegetable life, forming the black deposit described by Mr. McCauley.

It is manifest that temperature, constituting, as it were, the climate of the springs, has more to do with these developments than the chemical constitution of the water. In the hotter of the springs, those with a temperature from 141° to 127° Fah., the cellular fungus flourishes, with but little incroachment on its territory by the red-membraned zoophyte or nullipore. Where the water has a temperature ranging from 127° to 101° Fah., the zoophyte finds its favorable conditions. Nos. 7, 12, 16, and 17, where the coralloid secretions are most marked, have temperatures, respectively, of 101°, 102°, 107°, and 110° Fah. In the outflow of the springs on the southern slope, with a high temperature, the lower algæ are predominant, and in 18 and 19, with the comparatively low temperature of 99° Fah., decreased still more in outflow channel, is found the higher form of this aquatic vegetation. The mud of the cold springs differs from the hot-water deposits in being a true deposition of suspended rock detritus. In their waters the lowered temperature accounts for the absence of the organic developments which characterize those of the hot springs, but the absence of a selenitic lining to the basins is indicative of a different constitution to the contained waters, or at least of such a dilution of the sulphated and carbonated waters as would interfere with crystalline precipitation. But, on the other hand, the presence of sulphur in the mud, the situation of the basins in the same cretaceous rock, the mound or crater-like elevation on which they are placed, together with the existence of sulphuretted springs on Ojo Frio Creek, suggest a certain relationship to the Great Hot Spring and a more active history in the past than they have in the present. If these holes at one time contained, as seems probable, a water approximating in temperature and constitution to that of spring No. 1, the change which reduced them to their present condition must have been cataclysmic, for had it been gradual lowering of the temperature as the connection with central sources of supply was cut off, would have given favorable opportunity for the filling up of the cavities with zoophytic secretions, and their site would now be recognizable only by the distinctive red color of the rock, as seen in the recent closure of spring No. 8. At Pagosa it would appear, from a consideration of the water and specimens examined, that there exists a fissure of limited size in the subjacent impermeable rocks, through which water wells from a great depth into a deep and narrow crater-like cavity in the superficial cretaceous stratum. The water makes its exit from below with insufficient force to carry it clear of the rim of the cavity, so that it has to find an outflow through the permeable surface layer into the San Juan cut by channels which lie at no great depth, as they are tapped in several places by secondary springs, and issue at the present time on a plane six feet higher than the surface-water level. Beneath this water level the cretaceous rock is, of necessity, more or less water-logged, the movement being percolative and unnoticed to the river bottom farther down the stream, or through water-worn crevices, such as lead to notable exits on the Ojo Frio Creek. Some small channels of this character underlie the gravel bed of the San Juan River, crossing it, and forming the shafts of supply of the cold springs, the water of which has become diluted and lowered in temperature by surface admixture.

The water which rises from the depths into the basin of the main spring is charged with sulpheretted gas, which is immediately disengaged into the atmosphere, or decomposed with precipitation of sulphur at the moment of its contact with the air. Enough of the gas, however, remains in solution to carry by its slow oxidation the sulphur taint wherever the water is distributed. Its solids, amounting to about 1 pound in 350, are essentially calcium as bicarbonate and sulphate and sodium as sulphate, the latter constituting two-thirds of the total amount. A water of this character will develop stalactites under favorable conditions, and will incrust foreign bodies by soakage and subsequent evaporations; but the only change which will occur in it when uninfluenced by extraneous forces is the slow depositions in crystalline form of the calcium sulphate. All other deposits apparent in the water, which would seem to indicate singularity in its constitution, are due not to the presence of unusual mineral substances but to organic developments. This report might with propriety close here, as the geologic history of the springs can readily be constructed from what has been said of their chemistry and topography. But as a misconception is current with regard to them, based on their magnitude and singularity and on a misapprehension of the nature of their deposits, and besides as much popular interest attaches to them in view of the probable standing which they will hereafter assume among the invalid resort of the country, a few words explanatory of their relation to their past and present surroundings may not be out of place. On account of the rapid filling up of the swamps to the southward of the main spring by deposition, incrustation, and organic secretion, the cretaceous rock in which the springs are situated has been considered as built up around them by the waters. They are supposed to have antedated the stratum to which they now channel their way to the surface water level. This involves the original confinement of the upspringing water in a basin formed by the surrounding hills, with evaporation from the surface and deposition at the bottom, until the solid stratum obtained a level at least as high as that which it now possesses on the right bank of the San Juan River. It further infers the construction, by the same agency, of the existing cavity of the main spring prior to the advent of the river on the surface of the cretaceous bed. The unknown extent of this calcium stratum, lost as it is under superincumbent layers on the north, and undefined as its margins are in all directions, might be brought forward as an objection to this theory of its formation; but to controvert the hypothesis requires only a consideration of the existing basin of spring No. 1; given a flow of water, such as is above described, from the deeper layers of the earth's crust into the bottom of an inclosed valley, its surface would rise and spread until an equable water level was established by evaporation. After this was accomplished deposition of calcium salts would go on, layering the bottom and raising the surface until the *vis a tergo* was neutralized, or until an outflow was reached for the now concentrated saline waters in the brim of the containing valley.

In the former case consolidation would be effected by evaporation, but as this agency would be most active at the shallowest part of the basin, the deposition would advance from the circumference to the center, forming a saucer-like calcium bed around the inflow, in which the sodium salt would concentrate and crystallize. In the latter event, inasmuch as evaporation still continued, deposition with consequent elevation of the bottom would drain off the water in excess of its inflow, and so lessen the size of the saline lake. At the same time erosion, by deepening the outflow, would contribute to the withdrawal of the waters until ultimately the transformation of the original valley into a stratum of calcareous rock with a lakelet or pond overlying the spring would be effected. If subsequent to this the fresh waters of the San Juan River appeared on the surface of the calcareous basin at its upper end, their tendency would necessarily have been towards the center of the saucer-like depression or pond incorporating its upspringing inflow as a subterranean tributary, and utilizing its outlet for their farther course. The springs in our time would thus well up in the current of the San Juan River. But, were the San Juan assumed, on account of some accidental formation of the calcareous surface, the record of which is now lost, to have struck the outlet of the pond without breaking in upon its cavity, a nearer approach to present conditions would result; the river in course of time, by deepening its channel and lowering the surface water level, would drain that portion of the porous rock which lay on a higher plane; and when the level fell lower than that at which the waters of the spring were preserved by their *vis a tergo*, the saline pond, instead of overflowing and seeking the river by its surface channel, would penetrate the sides of its basin and reach its destination by underground filtration. But in this event, although the spring would be preserved, isolated from the river, its site would be a depression on the cretaceous surface instead of the existing prominence. In short, by no assumption can the mound and crater-like rim of the great basin be made to accommodate themselves to a theory of deposition from the waters now therein confined. This fact is even more patent in the case of the Cold Springs.

That the same forces which constructed the great basin were concerned in their formation will readily be conceded; but on the low mound at this point there are three cavities, and it is impossible to conceive the construction of their common elevation and the partitions between them by any process of deposition.

The force which caused the elevation and gave the crater-like rim to the great basin must have been one which acted from below. The cretaceous rock must have existed not only previous to the advent of the San Juan River, but previous to the irruption of the sulphuretted waters from the underlying strata—is surface-level as when first deposited by the carbonated waters of a previous era. On this assumption the history which led to the present status of the springs can be read so plainly as to warrant the acceptance of the assumption as a demonstrated fact.

Granting, then, its pre-existence at this part of the San Juan Valley, the next step is the breaking down of a subjacent barrier and the entry of the subterranean waters into the porous stratum, under a pressure from below which suffices to water-log the whole thickness of the stratum. The water, by its charge of free carbonic acid, is enabled to attack the rock and channel an upward course toward the superficial crust. The action is most vigorous in the line of the upward current, and a cavity is here formed. Cavities are also excavated at weak points in the neighborhood, all of them, however, being situated near to the surface of the rock, as here the disengaged gas accumulates and is most efficient as a solvent of the chalk. Thus a water-pocket is formed over the issue-point of the spring, from which channels radiate leading to others, notably to three about a half a mile south of the main pocket the cavities enlarge; the steady pressure of the confined gases upheaves the thin layer of crust which covers them, until a break occurs, when the rush of escaping gas caves in the roof and the springs are formed.

The surface of the plain has been altered by this event. At the main spring, where the maximum of force was exerted, is found an abrupt mound or mammiform elevation, with a break in the continuity of its rounded apex, crater-like in appearance, wherein are exposed the bubbling waters. In addition to the mound there is a slight upward dislocation of the stratum, which gives the surface a correspondingly slight fall in all directions from the center of eruptions until it is lost in the general level of the unaffected part of the plain at a distance of two or three hundred yards from the crater.

At the now cold springs, which are situated near where the calcareous stratum is overlaid, less favorable conditions for dislocation are found; and besides, on account of their distance from the main issue, the irruptive force has been less powerful.

It is unlikely that overflow followed the opening of the springs, for the escape of their waters would have repaired the inequality of level by calcareous deposition, and the San Juan would not now occupy its present bed. It is to be supposed, therefore, that however active the gaseous disengagement the water movement was sluggish, being solely by percolation through the porous rock to a surface overflow, perhaps where the Ojo Frio now runs, or perhaps beyond this at a site long since obliterated by the establishment of more direct channels. At this time a lime sulphate lining to the cavities, fissures of upheaval, and channels of dissection was being crystallized, strengthening the walls of the water-courses and preserving the rock from disintegration. The line of least resistance in the cretaceous bed must have run from north to south, as not only does the long diameter of the main cavity lie in this direction, but also the principal fissures of upheaval. They extended on the north as far at least as the present river-bed and on the south to the Cold Springs. On the northward extension the formation of secondary springs was aided by the erosive action of rain to which its elevation now exposed the surface. Whether such were formed on the southward extension is unknown, as the record is obliterated.

The San Juan River, on its appearance on the scene, followed the curved line of low level around nearly three sides of the eruptive mound, forming its horseshoe bend. As the bottom deepened the northern extensions from the spring were cut, and those issues permitted to the water which now constitute springs Nos. 9 and 10. These underground channels, lined with solid calcium sulphate, pre-existed and were laid open by the erosion of the river. Had they been formed by percolation after the San Juan cut was established they would have opened nearer the present surface-level. Since that time they have continued to flow as they now do, being prevented from sinking by the crystalline lining and organic deposits and from being occluded by zoophytic growth, the only actively constructive agent in these waters, by the high temperature which results from their direct communications with the main spring. The selenite lining thus antedates the period when the river-bottom was 6 feet higher than is the present surface. As the river turned the southern aspect of the mound, the southward extension of the upheaval fissures which supplied the springs on the opposite bank were broken into and those openings were reduced to their present status. But here, probably on account of thinness of the superficial crust and somewhat of parallelism in the lines of direction of the fissures and river-current, the San Juan appears to have effected more surface erosion than on the northern aspect of the mound. There has been here inundation until the deepening river-channel withdrew the waters, leaving the edge of the calcareous plain much lower than on the north, and a pond instead of previous subterranean cavities between its bed and the main spring. The pond, fed by the cut end of former underground channels, now the springs on the southern slope, became subsequently filled up by evaporative deposition to its present condition of swamp.

Corresponding with the deepening of the San Juan River channel must have occurred, by subsoil movement to the surface water level, a fall in the waters of the main spring, subsidiary openings, and its connecting cavities; the last condition yielding at the present day the hollow sound when the surface is heavily trod upon; at the same time certain high-planed effluents of the main spring have been gradually deprived of their water supply, causing slowness of current and lowering of temperature. The former result permitted the formation of stalactical masses under the overhanging edges of the river cut; and the latter afforded the needful climate for the rapid development of the polyps, which have ultimately obliterated these channels and the pockets connected therewith, leaving a record of their existence as coralline rock. The porosity of the calcareous stratum necessarily implies this variation in the level of the spring corresponding with the fall in the river surface, and those who hold that the spring level is higher during the month of June, when the surface water level is raised by snow melting, have no doubt made accurate observations.

CH. SMART,
*Captain and Assistant Surgeon, U. S. A.*

FORT PREBLE, *Portland, Me., June* 9, 1879.

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## RR 2.

## ANNUAL REPORT OF LIEUTENANT C. A. STEDMAN, ACTING ENGINEER OFFICER, FOR THE FISCAL YEAR ENDING JUNE 30, 1879.

### EXPLORATIONS AND SURVEYS IN THE DISTRICT OF NEW MEXICO.

HEADQUARTERS DEPARTMENT OF THE MISSOURI,
OFFICE OF THE CHIEF ENGINEER,
*Fort Lewis, Colorado, July* 14, 1879.

SIR: Since forwarding my annual report I have received a report from Lieut. C. A. Stedman, Ninth Cavalry, acting engineer officer District of New Mexico, of the operations of his office during the past year, and I inclose herewith the greater part thereof and request that it be annexed to my prior report.

I am, sir, very respectfully, your obedient servant,

E. H. RUFFNER,
*First Lieutenant of Engineers.*

The CHIEF OF ENGINEERS,
*United States Army.*

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HEADQUARTERS DISTRICT OF NEW MEXICO,
OFFICE OF THE ACTING ENGINEER OFFICER,
*Santa Fé, N. Mex., July* 2, 1879.

SIR: I have the honor to forward herewith tables exhibiting the work in which this office has been engaged during the fiscal year ending June 30, 1879. It will be seen in Table A that, besides the usual clerical work of the office, twenty-eight drawings and twenty-four tracings have been made. Twenty-one of the drawings, on a scale of 1 inch to 4 four feet, were "elevations of the buildings at Fort Marcy." There being no reliable data concerning their dimensions at this office, it was necessary to take all the measurements. Reports of scouts, amounting to 9,326 miles, have been received and acted upon by this office, as shown in Table B, inclosed.

Although the work performed by the troops is extensive, it is to be regretted that the notes taken were not more satisfactory; but it is supposed that the nature of the duty connected with the principal number of scouts prevented a strict compliance with existing orders.

Sergeant Maier, Company D, Battalion of Engineers, was discharged May 7, 1879, whereby the strength of the engineer detachment in this district was exhausted.

Besides the work above quoted, I have been engaged for a month and a half in the survey of a military reservation for a new post near El Paso, Texas.

One hundred and twenty maps have been issued and much information has been furnished to travelers. In addition I inclose copies of two reports of 1877, the originals of which were forwarded to the acting assistant adjutant-general District of New Mexico, where it appears they were retained.

I am, sir, very respectfully, your obedient servant,

C. A. STEDMAN,
*First Lieutenant Ninth Cavalry,*
*Acting Engineer Officer District of New Mexico.*

The CHIEF ENGINEER OFFICER,
*Department of the Missouri.*

A.—*Topographical work done in engineer office, District of New Mexico, July 1, 1878, to July 1, 1879.*

| Nature of drawings and tracings. | Number of drawings. | Number of tracings. | Date of office work. | Authority. | For whom. |
|---|---|---|---|---|---|
| | | | 1878. | | |
| Route from Fort Garland, Colo., to Santa Fé, N. Mex. and San Juan, N. Mex., to Alamosa, Colo. | 1 | 1 | August | Lieutenant Stedman | Engineer office, District of New Mexico; chief engineer, Department of Missouri. |
| Scout of Captain Carroll, Ninth Cavalry, in Guadalupe and Sacramento Mountains. | ..... | 1 | September | Captain Carroll, Ninth Cavalry. | Engineer office, District of New Mexico. |
| Route from Rio La Plata to Fort Garland, thence to Conejos via Alamosa. | 1 | ...... | October and November. | Sergeant Maier, engineers | Engineer office, District of New Mexico. |
| Major Morrow's scout from Rio La Plata to White Mesa, Ariz. | 1 | ...... | October | Sergeant Maier, engineers | Engineer office, District of New Mexico. |
| Report on Pagosa Springs by Lieutenant McCauley (copy made and retained). | *2 | 21 | December and January. | Lieut. C. A. H. McCauley | Engineer office, District of New Mexico. |
| | | | 1879. | | |
| Ground plan of Fort Marcy, N. Mex. (scale 100 feet to the inch). | 1 | ...... | January | Lieut. C. A. Stedman, Private G. A. Lichtenburg. | Chief quartermaster, Military Division of Missouri. |
| Elevations of buildings at Fort Marcy, N. Mex. (scale 4 feet to the inch). | 21 | ..... | January and February | Lieut. C. A. Stedman, Private G. A. Lichtenburg. | Chief quartermaster, Military Division of Missouri. |
| Survey of military reservation for proposed military post authorized near Fort Bliss, Tex. | 1 | ...... | April | Lieut. C. A. Stedman, Private G. A. Lichtenburg. | Engineer office, District of New Mexico. |
| | .... | 1 | May | Lieut. C. A. Stedman, Private G. A. Lichtenburg. | To accompany report forwarded. |
| Route from Rio La Plata to Fort Garland, thence to Conejos via Alamosa. | ...... | 1 | May | Sergeant Maier, engineers | Chief engineer, Department of Missouri. |

* Pencil copies.

C. A. STEDMAN,
*First Lieutenant, R. Q. M. Ninth Cavalry,*
*Acting Engineer Officer District of New Mexico.*

B.—*Scouts and marches in the District of New Mexico from July 1, 1878, to July 1, 1879.*

| Number of L. R. | Nature of scout or march. | Date. | Number of miles. | Name of recorder. | Remarks. |
|---|---|---|---|---|---|
| 1878.<br>52 | Scout from Fort Stanton to Roswell, Lincoln County, N. Mex., and return. | June, 1878 | 254 | Capt. G. A. Purrington, Ninth Cavalry. | Sketch received July 5; descriptive notes, September 3. Returned with remark that General Order No. 4 has not been complied with. |
| 53 | Scout up the Dolores and Mancos Rivers. Also, scout of Lieutenant Humphreys. | May, 1878 | 350 | Major Morrow and Lieutenant Humphreys, Ninth Cavalry.<br>Sergeant Maier, Company D, Battalion of Engineers. | Sketch returned as unserviceable. General Order No. 4 has not been complied with.<br>Instrumental notes furnished. Platted engineer office, district of New Mexico. |
| 57 | Scout from Fort Bayard to Gila River and return | July 31 to August 4, 1878. | 130 | Lieutenant C. A. Bradley, Ninth Cavalry. | Incomplete notes, and sketch returned for correction. |
| 58 | Scout from Fort Bayard | July, 1878 | 83 | Lieutenant J. A. Maney, Fifteenth Infantry. | Incomplete notes, and sketch returned for correction. |
| 59 | Scout from Guadalupe and Sacramento Mountains, south of Apache Indian reservation, and return, to Stanton. | July, 1878 | 882 | Capt Carroll, Lieut. Wright, and Lieut. Smith, Ninth Cavalry. | Report and sketch. Copy of sketch made for retention. |
| 68 | Scout from Fort Stanton | October, 1878 | 253 | Lieutenant G. W. Smith, Ninth Cavalry. | Report, returned with remark that General Order No. 4, district of New Mexico, series of '78, has not been complied with. |
| 71 | Scout from Fort Bayard, N. Mex., to Diamond Creek, and return. | October, 1878 | 153 | Captain H H. Humphreys, Fifteenth Infantry. | Descriptive notes, returned with remark that accurate notes could and should have been taken. |
| 72 | Scout from Fort Bayard to Cienega del Burro, Mogollon Mountains, and return. | October, 1878 | 283 | Lieutenant C. A. Bradley, Ninth Cavalry. | Descriptive notes and report, returned with remark that in pursuit of Indians better notes could not have been taken. |
| 73 | Scout from Fort Bayard to Cienega del Burro (command there turned over to Lieutenant Brady). | October, 1878 | 189 | Lieutenant J. A. Maney, Fifteenth Infantry. | Descriptive notes and report, returned with remark that in pursuit of Indians better notes could not have been taken. |
| 74 | March of Company D, Ninth Cavalry. Escort to survey a boundary between Utah and Colorado. | September and October, 1878. | 306⅛ | Lieutenant J. F. Guilfoyle, Ninth Cavalry. | Descriptive notes and report. Although neat, no use could be made of them, as no measurements or time for distance and no compass for courses had been used. |
|  | Route from Rio La Plata to Garland, viâ Conejos, thence to Conejos via Alamosa. | August, 1878 | 361 | Sergeant F. W. Maier, Company D, Engineers | Instrumental notes. Platted in engineer office, district of New Mexico. |
|  | Routes from Garland to Santa Fé and San Juan to Alamosa. | May and June, 1878 | 239 | First Lieutenant C. A. Stedman, Ninth Cavalry, A. E. O. | Instrumental notes. Platted in engineer office, district of New Mexico. |
| 76 | Scout in vicinity of Fort Bayard and Silver City | December, 1878 | 35 | Lieutenant C A. Bradley, Ninth Cavalry. | Descriptive report. |
| 79 | Scout from Fort Bayard to Fort Cummings, and return. | December, 1878 | 258½ | Capt. Beyer, Ninth Cavalry. | Descriptive notes, returned as of no value, no compass being used. |

| | | | | | |
|---|---|---|---|---|---|
| 80 | Scout from Fort Bayard, N. Mex., in pursuit of Indians. | December, 1878 | 358 | Lieut. Cusack, Ninth Cavalry. | Descriptive report. Circumstances prevented the taking of proper notes. |
| 81 | Scout from Fort Bayard, N. Mex | December, 1878 | 195 | Lieut. Bradley, Ninth Cavalry. | Descriptive notes, returned as of no value. |
| 1879. | | | | | |
| 3 | March of Company K, Ninth Cavalry, on escort duty to survey boundary between Utah and Colorado. | September 10 to November 29, 1878. | 758 | | Report, returned as of no value. |
| 4 | Scout from Fort Bayard, in pursuit of stolen stock | January, 1879 | 183 | Sergt. Carter, Company G, Ninth Cavalry. | Report. Under the circumstances proper notes could not be expected. |
| 4 | Scout from Fort Bayard, in pursuit of stolen stock | January, 1879 | 417 | Lieut. Hugo, Ninth Cavalry. | Report. Under the circumstances proper notes could not be expected. |
| 14 | Scout from Fort Bayard, N. Mex., Companies C and G, Ninth Cavalry. | January and February, 1879. | 264 | Capt. Beyer, Ninth Cavalry. | Report, returned as of no value. |
| 15 | Scout from Fort Bayard, N. Mex., Company B, Ninth Cavalry. | January and February, 1879. | 405 | Lieut. Hugo, Ninth Cavalry. | Descriptive report. |
| 16 | Scout from Fort Bayard to Florida Mountains, detachments of Companies B and G, Ninth Cavalry. | January and February, 1879. | 188 | Lieut. Bradley, Ninth Cavalry. | Descriptive report. |
| 17 | Scout from Fort Bayard to Knight's Branch and Cienega del Burro. | March, 1879 | 100 | Lieut. Emmett, Ninth Cavalry. | Descriptive report. |
| 19 | Report of route (table of distances) between Forts Craig and Bayard, on right of Rio Grande. | March, 1879 | 138.7 | Lieut. Hughes, Ninth Cavalry. | Table of distances |
| 20 | Scout from Fort Bayard to and in Mogollon Mountains. | March, 1879 | 184 | Lieut. Cusack, Ninth Cavalry. | Descriptive report. |
| 22 | Scout from Fort Bayard to Florida Mountains. | April, 1879 | 322 | Lieut. Emmet, Ninth Cavalry. | Descriptive report. |
| 37 | Scout from Fort Bayard to Mogollon Mountains and down San Francisco River, in pursuit of Indians. | May, 1879 | 284 | Maj. Morrow, Lieuts. Cusack and Maney. | Descriptive report. |
| 38 | Scout from Fort Bayard to Fort Cummings and return, and in Florida Mountains. | May, 1879 | 626 | Lieut. Wright, Ninth Cavalry. | Descriptive report. The nature of the duty performed prevented the taking of notes. |
| 40 | Scout from Fort Bayard to Ojo Caliente, via North Star road. | May, 1879 | 280 | Lieut. Hugo, Ninth Cavalry. | Descriptive report. Returned with remark that General Order No. 4 has not been complied with. |
| 41 | Scout from Fort Bayard to Florida Mountains, Ojo Caliente, Cummings, &c. | May and June, 1879 | 369 | Capt. Beyer and Lieut. Wright, Ninth Cavalry. | Descriptive report and notes. Returned with remark that General Order No. 4 has not been complied with. |
| 42 | Scout from Fort Bayard along San Francisco River, Mogollon Mountains, &c.; Lieutenant Cusack. | May and June, 1879 | 39.6¼ | Lieut. Maney, Fifteenth Infantry. | Descriptive notes, very neat. Returned, General Order No. 4 has not been complied with as regards the use of instruments. |
| 43 | Scout from Fort Bayard, N. Mex., in pursuit of Indians. | June, 1879 | 61 | Lieut. Wright, Ninth Cavalry. | Descriptive notes. |
| | Total | | 9,326 | | |
| | Military survey of reservation for military post near El Paso, Texas; 132 acres, 15 rods, 17 yards, 1 foot. | April, 1879 | | Lieut. Stedman, Ninth Cavalry, A. E. O. district.<br>G. A. Lichtenberg, G. S., U. S. A. | Platted in engineer office, district of New Mexico. |

C. A. STEDMAN,
*First Lieutenant and R. Q. M., Ninth Cavalry,*
*Acting Engineer Officer, District of New Mexico.*

## RECONNAISSANCE FROM SANTA FÉ TO FORT STANTON, N. M., BY LIEUT. C. A. STEDMAN, ACTING ENGINEER OFFICER, DISTRICT OF NEW MEXICO.

HEADQUARTERS DISTRICT OF NEW MEXICO,
OFFICE OF THE ACTING ENGINEER OFFICER,
*Santa Fé, New Mexico, August* 11, 1877.

SIR: In compliance with letter of instructions from your office under date of May 11, 1877, I have the honor to render the following report of the route from Santa Fé, New Mexico, to Fort Stanton, via Dow's Agency, at the Gallinas Mountains.

Pursuant to paragraph two, S. O. No. 36, current series, Headquarters District New Mexico, I left Santa Fé on May 19, accompanied by Private E. H. Wilton, general service clerk, of my office, for Galisteo, New Mexico, en route to Fort Stanton, New Mexico.

Galisteo, a Mexican town of about four hundred and fifty inhabitants, situated on the right bank of the Galisteo Creek, 22.08 miles due south of Santa Fé, is the first settlement en route to Fort Stanton.

The road between the two towns, an excellent mountain one, passes over the foot-hills of the Santa Fè Mountains, through a country covered with scrub cedar, pinon, and good grass, and having a rapid descent toward the valley of the Galisteo.

The forage agency at Galisteo, kept by a Mr. Davis, was found to afford good accommodations for officers and men, safe corral for a large number of animals, but no stable for shelter. Forage, long and short, was of good quality. Owing to the numerous herds of cattle and sheep of the inhabitants of the town the grazing in its vicinity for 2 miles was poor.

Leaving Galisteo May 20, I proceeded to McAfee's ranch at Antelope Spring, situated 40.88 miles west of south from Galisteo, over a fine natural road passing over a rolling prairie country, sloping toward the south, and which may be considered as the valley between the mountain ranges forming part of the eastern shed of the Rio Grande Valley on the west, and the western shed of the Pecos Valley on the east.

Grass of an excellent quality (crow-foot or white grama) is abundant almost the entire route; but the country is entirely destitute of wood, and almost of water.

Twenty-six miles from Galisteo is Stinking Hole, the only intermediate point on the road where water can be obtained. It is situated about midway of a belt, some three miles wide, of alkali country. Two small holes containing water of bad quality were found here. I was subsequently informed that this water was permanent, and judging from the shallow holes and the evident feeble attempts to obtain good wells, I am of the opinion that water in abundance and of fair quality could be procured by sinking deep wells.

As the water holes now are, sufficient water for a command of the size of a troop of cavalry could not be obtained.

The country from Stinking Hole to Antelope Spring is a continuation of rolling prairie country, with fine grass and entirely destitute of wood.

McAfee's ranch is in a bare open country, close by the spring, (Antelope,) which is about 6 feet in diameter, flows copiously, and supplies a great quantity of hard water of good quality, sufficient for a large command and many animals.

The grazing in the vicinity of McAfee's was poor, the grass having been eaten off by cattle.

The country is entirely destitute of wood. The people of the ranch have to go some 15 miles for their wood.

The accommodations at McAfee's forage agency were very inferior both for man and beast.

Leaving Antelope Spring on the morning of May 21, I proceeded to Dow's agency, at the Gallinas Mountains via Dow's new road.

At Antelope Spring no guide could be procured to accompany me, and I was obliged to proceed, having obtained all the information that could be derived from Mr. McAfee concerning the route and country.

From this point my letter of instructions required that odometer measurement should be taken via Dow's new road to Jicarrilla station. In making these measurements two odometers were used, from which a mean measurement was taken as the true one.

Antelope Spring is situated on the northern limit of an extensive basin of alkali country containing many alkali and salt lakes.

The route traversed leaves Antelope Spring over the Stanton and Antelope Spring road via Las Animas and Las Posos Pinosos, extending in a southeastern direction for 18.86 miles, when it branches off more to the south, leaving the old road to the left.

That part of the old road which is traveled passes over an alkali flat thickly covered with sage brush for 11 miles as far as the salt lakes; it then meanders through the salt lakes (nine in number) for about 7 miles, and which is by far the worst part of the road between Antelope Spring and Dow's agency, being very hilly, and the soil of such a nature as to be very dusty and sandy in very dry weather, and slippery and heavy in wet seasons.

Dow's road leaves the old road 1¼ miles after passing the last salt lake, and passes in a south-south easterly direction over a rolling, open, and good grass country, grade of road slightly ascending and soil good for roadway for about 7½ miles, when it passes over a low ridge to high rolling prairie of sandy soil. From this point for 7½ miles the road is of heavy sand.

The grazing here becomes poor, and continues so till within about three miles of Dow's agency—that is, the grazing on about 18¾ miles of Dow's road is poor.

The road passes over the high rolling prairie above referred to for 4 43 miles, when it begins to descend, and passes over an open country for 5¾ miles. The aspect of the country here changes and cedar brushes abound, and one mile and one-third further on low timber. The country again becomes open and level prairie for about a mile, when it again changes and the road passes through cedar of stunted growth and pinion, becomes free from sand, and taps one-half mile from Dow's agency an old road which runs between the latter place and Alkali Holes.

I arrived at Dow's agency at 4.05 p. m., having left Antelope Spring 6 a. m., and found that the ranch consisted of a small log shanty of one room only, no corral for protection of animals, and that the spring (Gallinas) was one and a half mile from the ranch, up a narrow and rough ravine in the mountains, to which the mules had to be driven to water. Grazing in the immediate vicinity of the ranch was fine, and the country heavily wooded.

In recapitulation: the road from Antelope Spring to Dow's agency is by odometer measurement 44.76 miles; 18.86 miles of this distance is over the Antelope Spring, Los Posos Pinosos, and Fort Stanton road. The entire route is destitute of water that can be used for man or beast; the new portion of road (Dow's trail) 25.90 miles in length, passes over a generally rolling country, soil of which is more or less sandy, and of which 7½ miles is of heavy sand; grazing is poor the greater part of the way (18¾ out of 25.90 miles) and there is no wood for the first 13 miles after leaving the salt lakes. Dow's road is not sufficiently broken to make a good one for heavily loaded wagons, it being at present merely a wagon trail sufficiently plain to be easily followed.

I left Dow's agency on the morning of the 22d, and proceeded to Jiccarilla, or Livingston's station, in the Jiccarilla Mountains.

The road leaves Dow's in a southeast direction and passes over a hilly, mountainous, well-wooded, and fine grass country, till it takes the Antelope Spring, Los Posos Pinosos, and Fort Stanton road 5¼ miles from Dow's agency, whence it continues on that road to Jiccarilla Station.

The hills are not steep, and an excellent road could be made on this part of Dow's trail. From the junction of the two roads the route continues ascending through a mountainous country, becoming more hilly in approaching the Jiccarilla Mountains. The hills, however, are not steep and the road is excellent, and is of good grade throughout.

The distance from Dow's agency to Jiccarilla station by odometer measurement is 29.18 miles, five and a half of which are over Dow's trail.

The entire route is destitute of water. I was informed by the ambulance driver that about 10 miles from Dow's and about three and a half to the right and west of road up a cañon of the Gallinas Mountains there is a running spring of water. Ryan, my informant, pointed out to me the cañon where the spring could be found, and stated that he had been at the spring and knew of its existence.

The Gallinas and Jiccarilla Mountains, through which this part of the route passes, abound in pine timber suitable for lumber and building purposes.

Jiccarilla station is situated in Jiccarilla cañon and six and a half miles from Jiccarilla Spring on which the station people have to depend for water in the dry season, and which they transport to the ranch.

Mr. Livingston, owner of the ranch, has dammed a ravine close by the house, by which means he can catch water sufficient for his use at the station and travel on the road during the rainy part of the year. At this station two wells have been dug, one 108 and the other 35 feet deep, but water has not been reached in either, and work on them has been suspended.

The Jiccarilla Spring discharges about two barrels per day in ordinary seasons, but in very dry weather its discharge becomes reduced to twenty-five gallons.

Grazing in the immediate vicinity of the station is poor, but some distance from there among the mountains fine "mountain" or "blue grama" can be found in abundance.

The forage agency kept by Messrs. Livingston & Winters affords good safe corral and stable for a small number of animals, but no accommodations for officers or men. The station would not be selected as a safe camping-place, as it is in a cañon; the mountains on either side are precipitous and heavily timbered (pine), affording excellent cover in the immediate vicinity for an enemy; the place would be commanded from the surrounding mountains, and there are but three roads over which wagons could be taken, and which could be easily obstructed or held by a small force.

The drive made on the 23d of May was from Jiccarilla station to Fort Stanton. The route now traveled leaves the old road via Jiccarilla Spring about one-quarter of a mile from the station, and leaving it to the right extends in a southeasterly direction .87 mile, when it rejoins the spring road.

The road continues from Jiccarilla station through a heavily-timbered (pine) and mountainous country for 4½ miles and ascending; the hills are of good grade, however, and the roadway is excellent. The road there begins to descend, and debouches into the valley between the Jiccarilla Mountains in the west and the Capitan Mountains in the east.

As the road leaves the Jiccarilla Mountains the country becomes more open and the road passes over a hilly and rolling country from this to Fort Stanton.

Patos Spring, by odometer measurement 11.15 miles from Jiccarilla station and 21.16 miles from Fort Stanton, is a small running spring about 2 feet deep and about 3 feet across either way, the water of which was very filthy, made so by sheep and hogs. There are two small shanties inhabited by Mexicans close by the spring.

The country throughout from Patos Spring to Fort Stanton is a fair grazing and sparsely-wooded country, but entirely destitute of water on the roads as far as the Rio Bonito, about two miles from Fort Stanton.

Resume of route from Santa Fé to Fort Stanton, N. Mex., via Dow's trail. From Santa Fé to Galisteo, 22.08 miles; good road; fair supply of wood and grass; no water.

From Galisteo to Antelope Spring, 40.88 miles, fine road; good grazing; no wood and no water except at Stinking Hole, 25.88 miles from Galisteo; quality of water bad.

From Antelope Spring to Dow's agency, Gallinas Mountains, 44.76 miles; road over bad alkali flat, salt lakes and sandy country; grazing for greater part of way poor; no water, and wood scarce for more than two-thirds of distance.

From Dow's ranch to Jiccarilla station, 29.18 miles; road good through mountainous country, well wooded and fine grazing, no water.

From Jiccarilla Station to Patos Spring, 11.15 miles; road good through a mountainous country, well timbered; fair grazing on top of mountains, no water.

From Patos Spring to Fort Stanton, 21.16 miles; fine road over open and rolling country; wood obtains at intervals; grazing fair, no water between Patos Spring and Rio Bonito.

Total distance from Santa Fé to Fort Stanton 169 34 miles; 4.86 miles shorter than the route by Los Posos Pinosos.

### FROM FORT STANTON TO FORT SELDEN.

The transportation by which I was to go to Forts Selden and Bayard arrived at Fort Stanton on May 25.

I left the latter post May 27 for Dowlin's Mill *en route* to the former posts, and made the following drives and continued the odometer measurements:

From Fort Stanton to Dowlin's mill; distance 17.44 miles.
From Dowlin's mill to Blazer's mill; distance 16.74 miles.
From Blazer's mill to Tulerosa; distance 15.34 miles.
From Tulerosa to Shedd's ranch; Distance 55.39 miles.
From Shedd's ranch to Fort Selden; distance 27.04 miles.

My letter of instructions required that the direct road from Shedd's ranch to Fort Selden should be measured by odometer. This was carefully done, and the magnetic bearing of road taken.

The route passes first over the Organ Mountains through San Augustine Pass, then over an open country between the latter and the hills near and east of Fort Selden, then around these to Fort Selden.

In detail, the road extends from Shedd's ranch in a northwesterly direction for 3.41 miles up a rapidly-ascending grade to San Augustine Pass of Organ Mountains. The pass proper is 2.17 miles in length and is an excellent road. From this pass the road debouches into the valley of the Rio Grande and forks on the west side 5.58 miles from Shedd's ranch, the right-hand road leading to Fort Selden, the middle road leading to Donna Anna, and the left-hand road leading to Los Cruces.

The country between the Organ Mountains and the hills east of Selden is open prairie, descending for about 7 miles and ascending about the same distance, the soil of which is sandy for the first part and clayey for the second; which makes the roadway heavy and good respectively. This part of the route could be shortened somewhat, as the road meanders considerably without any apparent cause.

The roadway becomes very sandy after it leaves the hills east of Selden, and for 2 miles it is very heavy. It then passes over hard ground, but becomes rough as it passes over hills and ravines till within a short distance of Fort Selden.

There is no water along the route, little or no grazing, and greasewood and sagebrush the only wood.

The total distance from Shedd's ranch to Fort Selden was found to be 27.04 miles—1.53 miles shorter than the route via Donna Anna.

A map, scale $\frac{1}{253440}$ or 4 miles to the inch, of the route from Santa Fé to Fort Selden, constructed by private Wilton, United States general service, accompanies this report.

I am, sir, very respectfully, your obedient servant,

C. A. STEDMAN,
*First Lieutenant Ninth Cavalry, Acting Engineer Officer, District of N. M.*

The ACTING ASSISTANT ADJUTANT-GENERAL,
*District of New Mexico.*

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## REPORT ON THE NORTH STAR ROAD—FROM FORT BAYARD TO THE CAÑON ON THE BLACK RIVER—BY LIEUTENANT C. A. STEDMAN, ACTING ENGINEER OFFICER, DISTRICT OF NEW MEXICO.

HEADQUARTERS DISTRICT OF NEW MEXICO,
OFFICE OF THE ACTING ENGINEER OFFICER,
*Santa Fé, N. Mex., October* 26, 1877.

SIR: I have the honor to submit the following estimates of work required on the North Star road from Fort Bayard, N. Mex., as far as the north side of the Black Cañon, to make it a passably practicable road, called for by my letter of instructions from your office, dated May 11, 1877.

The estimates are tabulated and accompany herewith, but to cause them to be fully understood a brief description of the road will be given and the work in detail described.

The road extends from Fort Bayard in a northeasterly direction up into the Mimbres Mountains via Santa Rita mines and for 18 miles till it reaches the Mimbres River, near Magruder's quartz mill, where it passes up the river valley for about six miles in a northerly direction. It then leaves the river and valley and passing over the western slope of the Mimbres Mountains in a northeasterly direction for about 94 miles, crossing in that distance Willow and Bear Creeks, Black Cañon and River, Diamond Creek, and the Gila River, and over much very rough, hilly, and mountainous country.

It then bears more to the east and passes to the east of the Lucra Mountains and west of the White and Moneca Mountains, debouches into the Rio Grande Valley, near Sabinal, where it intersects the river road.

On June 11 I left Fort Bayard, with fifteen days' rations for my party, which consisted of Sergeant Maier, Company D, Battalion of Engineers; Private E. H. Wilton, general service clerk attached to my office; and an escort of one non-commissioned officer and five privates Ninth Cavalry, and one escort wagon and driver, and proceeded to the Mimbres River, and commenced a reconnaissance of the North Star road.

My letter of instructions required:

"To examine the North Star road as far as the cañon on the Black River.

"You will make an estimate, and forward same to this office, of the labor required to repair that portion of the road reported badly damaged by floods and rendered impassable for loaded wagons. If the road, as constructed, is too near the bed of the stream, you will endeavor to find a route and make the estimate with a view to a road that can resist destruction by water. You will also examine the country for any practicable route leading from Ojo Caliente Indian Agency to Fort Bayard."

The road from Fort Bayard to Mimbres River passes over a hilly and rough country; but is practicable, and with some repairs could be made a good road.

From the Mimbres River to the cañon of Willow Creek, the road would be good if much traveled. At the latter place, 33 miles from Fort Bayard, the first really bad road and obstacle to a practicable route was encountered. The road crossed a deep cañon at a place known as Willow Springs. The descent into the cañon is made over a steep hill some 1,800 feet long, which had been made by the citizens of Grant County in 1875. The roadway was part excavation and part embankment. Water had acted on the latter where it joined the former, and deep and dangerous ruts and washouts were the consequents. The width of the roadway as built was from 8 to 9 feet.

On June 13, this hill was leveled and the grade found to be 672¼ feet per mile.

Leveling was also done to make the road 12 feet wide, and entirely of excavation, and from data taken 290 cubic yards of earth and 20 cubic yards of rock will be required to be taken out.

Bear Cañon hill was the next bad road, 10.21 miles from Willow Spring. This hill is exceedingly steep and much washed out, the roadway having been made of part excavation and part embankment. It leads down into a deep, narrow, and very rocky cañon. The hill was leveled June 14, and the grade found to be 862 feet to the mile, and the hill 1,100 feet in length; the roadway was narrow.

Data were taken to widen the roadway 4 feet, to be entirely of excavation, and leveled throughout, from which 340 cubic yards of earth excavation will be required.

The road between Willow Spring and Bear Cañon hill is hilly, but in its now untraveled condition may be considered fair.

Bear Cañon, which joins Rocky Cañon, is about one-half a mile long, and the roadway through it was fair and susceptible of being made good by travel over it. The sides of the cañon are high and precipitous, and pine of considerable size abound in abundance.

Immediately from Bear Cañon extends Rocky Cañon, which is narrow, very rough, and rocky; nine thousand five hundred feet long by chain measurement, and having a small creek running in its bed. This seemed to be a very serious obstacle to a practicable route. It is about 150 wide at its (southern) commencement and continues on an average about that width for 1,900 feet, in which distance the road extends along and crosses the creek nine times. The creek abounds in large rocks, and wherever the road passes into and crosses it the roadway is exceedingly rough. The hills on either side are steep, from 250 to 300 feet high, and covered with pine and pinon timber.

At 1,970 feet the road enters the creek-bed and continues in it for 180 feet; the cañon here is about 15 feet wide, with high hills on either side.

From 2,150 feet to 2,700 the cañon becomes wider and the road leaves the creek-bed, but crosses it at 2,400, 2,500, and 2,700 feet, the latter a bad crossing. At the latter crossing the cañon narrows and the roadway enters the creek at 2,850 and continues in it for 700 feet. This part of the road is very rough, immense rocks filling the creek-bed. The road from this point (3,600 feet) runs either alongside or in the creek to 3,860 feet. The cañon narrows, and the hills on either side are from 250 to 300 feet high.

From 3,860 to 5,200 feet the cañon becomes more open and the road better as it leaves the creek-bed; the road crosses the creek at 4,200 feet, 4,380 feet, 4,520 feet, 4,800 feet, and 4,920 feet.

From 5,200 to 5,500 feet the cañon narrows to about 15 feet, is very rough, and as the road takes to the creek-bed is correspondingly so.

From 5,500 feet the cañon becomes more open, and the road leaving the creek-bed becomes better up to 6,000 feet, when it becomes again very rough and rocky; the cañon narrows, and at 6,235 feet it is about 40 feet wide.

At 6,235 feet a trail leads to the left, which taps the main road after it has left the rocky cañon and passed over the long hill at the north end of the cañon, and which is shorter than by the main road.

Rocky Cañon from 6,235 feet, the point of intersection with the trail, continues about 40 feet wide and very rough and rocky to 6,730 feet. Immense bowlders and rocks here fill the bed of the creek, over which the road passes. The road then extends along the creek for 170 feet, when it again enters the bed of the creek and continues in it for 1,470 feet, over a very rough and rocky roadway. From this point to the end of the cañon the road becomes less rough, crosses the creek-bed at 8,950 and 8,980 feet, and at 9,100 feet enters the creek-bed and continues in it for 160 feet.

The road leaves the cañon at 9,500 feet and passes over a steep and long hill, which in places is much washed out, and requires repair.

Pine of considerable size, suitable for building purposes, abound throughout Rocky Cañon and surrounding country.

After making as careful a reconnaissance of the surrounding country as practicable in the time spent on this part of the road, and reasoning that the citizens of Grant County would not have adopted the line of route taken and performed so much labor on the hill on the north side of cañon without previously having thoroughly reconnoitered the country for a more practicable way, it was concluded to keep the Rocky Cañon as the line of the road, but to so far change its location as to put a road over the trail which leaves the cañon at 6,235 feet, thereby avoiding the extensive hill at the north-end side of the cañon, besides a large portion of the roughest part of the road, and shortening the distance.

For the road to go by the whole length of Rocky Cañon the following work would be required; distances estimates from the south end of the cañon:

At 600 feet, 140 feet of road would have to be built on the side of hill to the left.
At 1,650 feet, 150 feet of road built on the side of the hill to the right.
At 1,870 feet, 260 feet of the road to be built on the side of hill to the right.
At 2,700 feet, 1,160 feet of road to be built on hill to left of creek-bed.
At 5,160 feet, 400 feet of road to be built on side of hill to right of creek.
At 6,200 feet, 2,190 feet of road to be built on side of hill to right of creek.

Besides the changes of location of roadway, bridges would be required.

For the road to go by the trail: that part of the above work up to where the trail comes into the main road; after which a road would have to be constructed up a rocky cañon and over hills at a proper grade.

Data were taken from which it is ascertained that the route via the Rocky Cañon will require the excavation of 12,600 cubic yards of rock and 3,700 cubic yards of earth, the grubbing and clearing of 2.13 acres, and the construction of seven bridges.

The road to pass over the trail would require the excavation of 7,600 cubic yards of rock and 5,100 cubic yards of earth, 2¼ acres of grubbing and clearing, and the building of four bridges and one culvert.

The road after it mounts the long and steep hill at the northern end of Rocky Cañon passes over a rolling and well-wooded country; the roadway is excellent, and with the exception of a short part of country which becomes boggy in the wet season there is no obstacle to an excellent road from Rocky Cañon to the south hill of Black Cañon. Wood and water are abundant.

The Black Cañon with its lateral cañons, considered as one, is about 2¼ miles wide and between 2,000 and 3,000 feet deep. The road passes down one of the side cañons over a hill on which the greater part of the work done by the citizens of Grant County was expended. Here the roadway was made as all of them, work on hills of part excavation and part embankment. Much was done in this way, the roadway having been cut into the side-hill for about 5 feet; and that part of the hill worked is about 2¼ miles long.

Timbers had been placed on the lower side and the embankment part of the road filled in on them.

The natural slope of the hills on which the roadway was built is very steep, which caused considerable embankment, and as the foundation thereof is in many places of perishable matter, it would in time be liable to slide off and entirely wash away.

The road winds in among the hills and has several sharp turns, which require much cutting to make them safe, as the hill is very steep and the road passes on the edge of the cañon, where, if a wagon were to get off of the road on its lower side, it would be precipitated hundreds of feet below, or dashed into the tops of high pines, equally as disastrous.

The road as now built was finished for about 2¼ miles, where work was suspended; and then for 2,000 feet from the foot of the hill it has been laid out and partially worked, thus leaving a stretch of about 2,400 feet to be laid out and built.

To convey some idea of the steep grade of the hill, in addition to the brakes of the light escort wagon with my party being put on their fullest capacity, lariats had to be fastened to the wagon and all available men of the escort held back on the ropes to prevent a too-rapid descent and liability of running off into the cañon below.

Much of the road was badly washed out, and, the logs of the foundation in several places already having given away, it will soon become totally impassable for wagons.

From the place where the work had been suspended the temporary road, which has been traveled, passes down a hill, which is entirely unworked, and is at a grade of about 1 on 1, or at an angle of 45°.

That part of the work which commences at the bottom of the hill and has been laid out and partially worked is of good grade, and, if completed, will be the best portion of the road.

On June 15 leveling was done to find an approximate average grade of this hill and 4,400 feet chained, which included the lower portion of the road already laid out and that portion yet to be laid out and built. The latter was laid out but not staked, and data taken for a roadway 12 feet wide and entirely of excavation.

From data so obtained, estimates of work required to build the road on the portions yet to be built and that laid out and partially worked have been made. Estimates for work to repair the upper portion of the hill, to widen it by 3 feet, side cutting and widen the turns, have been made, but from a reconnaissance only, no instrumental measurements having been taken.

The road, after entering the cañon proper, crosses the Black River and passes down the stream for about three-quarters of a mile, crossing it four times again, and leaves the cañon by a hill nearly as long and as steep as that on the south side of the cañon. This hill had been worked by detachments of the Ninth Cavalry, and extensive and good work had been done.

The roadway is entirely an excavation and 12 feet wide. After two years' time, and little or no travel over it, it was in good condition. The entire road as staked would be about 1¼ miles in length, of which about 3,900 feet are complete, leaving 2,700 feet still to be built. The road as now broken leaves the complete part and passes up a hill to the top of the mesa, so steep as to be almost utterly impassable for loaded wagons.

A reconnaissance of the road to be built was made, from which estimates for the required work are herewith submitted, together with those of the route to this point.

My letter of instructions required estimates for the required work on the road up to this point, and before proceeding further with the report of the tour over the other parts of the North Star road and the intermediate country between that road and the Rio Grande and Ojo Caliente Indian Agency and Fort Bayard, the estimates herewith submitted will be explained.

While at Silver City I obtained all the information I could gather from the citizens concerning the work done by them and others of Grant County, the price of labor, &c.

Ascertaining that Mr. C. P. Crawford had been one of the principal men concerned, I applied to him for information, and he subsequently to my having been over the United States road furnished me with the subjoined letter.

The estimates submitted have been made on a basis as follows: Daily wages of common laborers, $1.25; daily wages of blacksmiths and foremen, $3; daily cost of transportation at the current prices of hire at Sante Fé, and cost of tools, &c., 80 per cent. of the wholesale prices at same place; a day's work to be ten hours in duration, and equivalent to 12 cubic yards per man. Cost of earth excavation per cubic yard, 36 cents, and cost of rock excavation, blasting, &c., $1.25 per cubic yard. The bridges to be made of logs, to be procured near their respective locations.

The estimates are only approximate, as much of the road needs more or less repairs, the obstacles to a practicable route only having been touched upon.

The estimated cost as given is undoubtedly not excessive; and the cost of building and making the entire road from Fort Bayard to Sabinal would probably cost $8,000 over and above the cost of road south of Black Cañon.

The route continues on from the Black Cañon over a high mesa, the sides of which, being rough and precipitous, cause the road to meander considerably from its general course to be passable for wagons.

With the exception of some sand, a few hills, which with repair could be made good roadways, the road is very good to Diamond Creek, 13.91 miles from the Black River.

After reaching Diamond Creek, the road extends up its valley for about two miles, when it passes over the divide between the latter creek and the Rio Gila, and passes up that river for about three-quarters of a mile to Camp Vincent. In crossing the divide a short, very steep, hill is encountered, known as the "Hog Back;" extensive cutting, or perhaps a change of location of the road, would be required here to make it a practicable route for wagons.

The location of that part of the road on the Rio Gila should be changed, which would require some extensive work, as the hills are steep and considerable cutting would be necessary. The road, as now laid out, is partly in the river-bed, and as the Gila is subject to extensive rises, all travel would be blockaded either at Camp Vincent or the lower crossing of the river.

From Camp Vincent the road passes over a rough mountainous country and through deep cañons for 13¼ miles. This part of the road was built by detachments of the Fifteenth Infantry.

There are four hills of very steep grade on the road before it enters the Apache or Sherman's Cañon. After it enters the latter the road is an excellent one, with the exception of a mile and a half at the north end of the cañon, where it passes through an extensive cienega and is consequently boggy.

Much corduroying has been done here, and more is required to make it a safe way for heavily-loaded wagons.

From Camp Sherman, situated at north end of cañon, to the point where the road to Ojo Caliente leaves the North Star road, about 3¼ miles from Paddy's Holes, the road is excellent, passing over an open and rolling country.

There is permanent water at Shaw's ranch, 12 miles from Camp Sherman.

The road from Paddy's Holes to Ojo Caliente Indian Agency is a good mountain one.

Pursuant to my letter of instructions, of June 17 to 20, with two men, I made a reconnaissance of the country between Camp Vincent, on the Gila River, and Ojo Caliente Indian Agency in search of a practicable route from the latter to Fort Bayard. Taking the trail traveled by the Southern Apache Indians on their removal to Arizona from their reservation, I found it to be a route over which a practicable road could be built, and, judging from all the information I could gather from officers who had scouted over that and country still east and south of that, I am convinced that the trail referred to would be the shortest practicable route, supposing the North Star road to form part of it.

On June 24 I reached Ojo Caliente with my entire party, having traveled via North Star road as far as its junction with the old Fort Tulerosa and Ojo Caliente road, thence by that road to the latter place.

By odometer measurements the route as traveled was 126.82 miles.

From Fort Bayard to Ojo Caliente via North Star road and the trail referred to the distance would be about 97 miles.

As my letter of instructions in requiring the reconnaissance for a practicable route from Fort Bayard to Ojo Caliente Indian Agency did not confine the route to either side of the Mimbres Mountains, I determined to return from Ojo Caliente to Fort Bayard to the east side.

Leaving Ojo Caliente June 25, I proceeded en route to Fort Bayard via Cañada Alamosa, Cuchillo Negro Polomas, Cottonwood, on the Rio Grande, and the Gavalan Pass through the Mimbres Mountains to Mimbres River.

The road till it strikes the Rio Grande is excellent, after which it is more or less sandy.

The road now most traveled from the Cottonwoods, on the Rio Grande, to Fort Bayard and Silver City leaves the Rio Grande a short distance below the Cottonwood Ranch and passes over the foot-hills near the river, over the northern end of the Goodsight Mountains and the Little Jornada, between the latter mountains and Cook's Range, over the northern point of the latter and eastern slope of the Mimbres Mountains, striking the Rio Mimbres at Brockman's mill, which is about 10 miles above the crossing of the same by the mail-route.

This is known as Brockman's road. June 27 I left Cottonwood, on the Rio Grande, with the intention of proceeding by this route to the Mimbres River; but through mistake took a blind road, which led to Mule Spring, north of Cook's Range, and into the valley of the Mimbres River through the Gavalan Pass.

There was no road through the latter, and it was with great difficulty that the escort wagon could be gotten through.

The mistake in taking the route via Gavalan Pass was perhaps fortunate, as I have been assured by good authority that if a road could be put through the Gavalan Pass, a good straight road could be run either to the town of Polomas or the head of the Polomas River, thereby shortening the route to the north and avoiding the sandy roads near the Rio Grande.

Till recently the trail through this pass and direct to Polomas River was a mail-route (pony express).

A road could be built through the Gavalan Pass.

On June 30 I returned to Fort Bayard. The route of return from Ojo Caliente to Fort Bayard was, by odometer measurement, 144.46 miles, 17.46 miles longer than by the North Star and Tulerosa and Ojo Caliente roads, and 47.46 miles longer than by the North Star road and Apache trail.

In comparison of the practicability of the three routes between Fort Bayard and Ojo Caliente that via Brockman's road Cottonwoods on Rio Grande, Polomas, and Cañada Alamosa is at present much the best, as it is a thoroughly broken road.

If a road were built to cross the eastern slope of the Mimbres Mountains through the Gavalan Pass, and from thence as direct as possible to the town of Cañada Alamosa, heading the intervening streams, it would probably be the shortest and most practicable route that could be selected between the two points.

Either route via the North Star road would have the advantage of an abundant supply of wood and water.

The route east of the Mimbres Mountains would not pass through so well a wooded country, but would have an ample supply of wood and water for practical purposes.

I am, sir, very respectfully, your obedient servant,

C. A. STEDMAN,  
*First Lieutenant 9th Cavalry,*  
*Acting Engineer Officer, District of N. M.*

The ACTING ASSISTANT ADJUTANT-GENERAL,  
*District of New Mexico.*

*Estimated cost of completing North Star Road, in obedience to a communication dated Headquarters District of New Mexico, 11th May, 1877.*

| Localities, &c. | Distances. | Quantity and nature of work. | Rate. | Amounts. | Total Amounts. |
|---|---|---|---|---|---|
| Willard Spring Hill: | | | | | |
| Completing roadway | 900 feet | Earth excavation, 290 cubic yards | $0 36 | $104 40 | |
| | | Rock excavation, 20 cubic yards | 1 25 | 25 00 | |
| | | | | | $129 40 |
| Bear Cañon Hill: | | | | | |
| Completing roadway | 1,100 feet | Earth excavation, 340 cubic yards | 36 | 122 40 | |
| | | | | | 122 40 |
| Black Cañon Hill, south side: | | | | | |
| Completing roadway from summit of plateau to end of work done. | 2¼ miles | Earth excavation, 14,100 cubic yards | 36 | 5,176 00 | |
| Completing roadway from bottom of cañon to commencement of work done. | 2,000 feet | Earth excavation, 1,490 cubic yards | 36 | 536 40 | |
| | | Three culverts | 10 00 | 30 00 | |
| Constructing roadway not worked | 2,500 feet | Earth excavation, 2,770 cubic yards | 36 | 997 20 | |
| | | Clearing and grubbing, 1 acre | 25 00 | 25 00 | |
| | | Three bridges | 20 00 | 60 00 | |
| | | | | | 6,824 60 |
| Black Cañon Hill, north side: | | | | | |
| Constructing roadway not worked | 2,700 feet | Earth excavation, 3,320 cubic yards | 36 | 1,195 20 | |
| | | Clearing and grubbing, 1 acre | 25 00 | 25 00 | |
| | | Three culverts | 15 00 | 45 00 | |
| | | | | | 1,265 20 |
| Rocky Cañon to trail: | | | | | |
| Constructing roadway where it has to be deflected from bottom of canon. | 2,100 feet | Rock excavation, 5,600 cubic yards | $1 25 | $7,000 00 | |
| | | Earth excavation, 2,100 cubic yards | 36 | 756 00 | |
| | | Clearing and grubbing, 1 acre | 25 00 | 25 00 | |
| | | Three bridges | 30 00 | 90 00 | |
| | | | | | $7,871 |
| Constructing roadway from trail to the foot of the mountain. | 2,460 feet | Rock excavation, 7,000 cubic yards | 1 25 | 8,750 00 | |
| | | Earth excavation, 1,600 cubic yards | 36 | 576 00 | |
| | | Clearing and grubbing, 1.13 acres | 25 00 | 28 25 | |
| | | Four bridges | 40 00 | 160 00 | |
| | | | | | 9,514 25 |
| | | Total | | | 25,726 85 |

| | | | | | |
|---|---|---|---|---|---|
| Change of location from trail to junction of roads over the mountain. | 5,200 feet | Rock excavation, 2,000 cubic yards | 1 25 | $2,500 00 | |
| | | Earth excavation, 3,000 cubic yards | 36 | 1,080 00 | |
| | | Clearing and grubbing, 1.25 acres | 25 00 | 31 25 | |
| | | One bridge | 25 00 | 25 00 | |
| | | One culvert | 15 00 | 15 00 | |
| | | | | | 3,651 25 |
| | | By old location | | | 9,514 25 |
| | | Saving of cost by trail | | | 5,863 00 |

HEADQUARTERS DISTRICT OF NEW MEXICO,
OFFICE OF THE ACTING ENGINEER OFFICER,
*Santa Fé, N. Mex., June —, 1879.*

Official copy.

C. A. STEDMAN,
*First Lieutenant Ninth Cavalry,*
*Acting Engineer Officer District of New Mexico.*

# APPENDIX S S.

## ANNUAL REPORT OF LIEUTENANT EDWARD MAGUIRE, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1879.

### EXPLORATIONS AND SURVEYS IN THE DEPARTMENT OF DAKOTA.

HEADQUARTERS DEPARTMENT OF DAKOTA,
CHIEF ENGINEER'S OFFICE,
*Saint Paul, Minn., July* 1, 1879.

GENERAL: I have the honor to submit the following report for the fiscal year ending June 30, 1879.

The engineer detail in this department at the close of the previous fiscal year consisted of myself as engineer officer, one topographical assistant, and a detachment of the battalion of engineers of one sergeant and three privates.

On August 23, 1878, Sergeant J. E. Wilson, Company D, Battalion of Engineers, was discharged the service by reason of expiration of term of service, and was immediately re-enlisted as topographical assistant under the provisions of General Orders No. 62, Headquarters of the Army, Adjutant-General's Office, July 3, 1877.

Private Adolph Goslin, Company A, Battalion of Engineers, was, at his own request, discharged the service August 10, 1878, per Special Orders No. 169, Headquarters of the Army, series of 1878. He was appointed clerk for the work of improving Missouri River above the mouth of Yellowstone, but has, in addition, performed the major part of the clerical duties pertaining to this office.

Topographical Assistant Durage, accompanied by two privates, left Saint Paul May 20, 1878, *en route* to Fort Keogh, Mont., to make a survey of the reservation of that post. This work was admirably done.

The area of the reservation is 90.05 square miles. Of these 12.25 furnished good grazing, 12.09 are adapted to cultivation, and the timbered area amounts to 2.67 square smiles. Bad lands constitute the remaining portion of the reservation.

The boundary lines of the reservation were carefully run, azimuth observations having been taken every 3 miles. The total careful chaining amounted to 66 miles. There were 62 mounds and 3 posts erected.

The astronomical work consisted of 144 observations for time and 142 for latitude.

The survey gives the following results:

Longitude, Fort Keogh, 105° 56′ 53″.08.
Latitude, Fort Keogh, 46° 23′ 11″.648.
with probable error ± 0″.97.
Altitude, Fort Keogh, 2,511.09 feet.

On March 24, 1879, a tracing of the map of the reservation, and on April 24, 1879, a tracing of the plan of Fort Keogh was forwarded to the Chief of Engineers. Sergeant Durage's report is forwarded herewith.

As stated in my last annual report, Lieutenant Hoffman, Eleventh Infantry, was, upon my application, directed to make a reconnaissance of the Moreau or Owl River, Dakota. He left Cheyenne Agency (now Fort Bennett, Dakota) April 28, 1878, returning on June 30, 1878. A copy of his report and a tracing of the map of his reconnaissance was forwarded to the Chief of Engineers on March 24, 1879. His work has been incorporated in the map of Dakota issued from this office.

Acting Assistant Surgeon Charles E. McChesney was ordered to report to me July 10, 1878, to collect information concerning the birds and mammals of the Big Horn region. An elaborate and valuable report submitted by him was forwarded to the Chief of Engineers March 24, 1879.

On August 28, 1878, I left Saint Paul, in charge of two parties, for the survey of the Yellowstone River, arriving at Fort Keogh September 6. Having started the survey of the Yellowstone and inspected the work of Topographical Assistant Durage, I left Fort Keogh with the whole detachment September 23, to proceed overland to Fort Buford.

Starting at 1 p. m., we encamped on Sunday Creek, a tributary of the Yellowstone, at 4.30 p. m., after a march of 9.6 miles. The next day we reached Custer Creek, 24.6 miles farther on. The road traveled was generally poor, but one portion of it, called "Butler's Cut Off," was very difficult of passage, it lying in a stretch of bad lands about 4 miles in width. Between Keogh and the valley of Custer Creek the land is poor. The grass was thin and of poor quality, and the water along the whole route was strongly alkaline.

The valley of Custer Creek, however, is a beautiful one, affording excellent grazing and is apparently fertile. The stream was well timbered and the water good. We met game for the first time in this valley. Buffalo and deer were killed within a mile of camp.

After leaving Custer Creek the next day, and having crossed a narrow strip of bad lands, we entered a fine rolling grazing country, stretching out in all directions as far as the eye could reach, the streams all well timbered and the landscape dotted here and there with the different varieties of game common to that region. The soil was a good black loam. With the exception of the drift fragments, the argillaceous sandstone so common to Dakota and Montana was the only variety of stone seen. At our next camp, on a branch of Bad Route Creek, specimens of gypsum and petrified wood containing beautiful crystals of lime were found in profusion. The timber there was scarce and the valley uninteresting. There was but little water, and that bad.

This valley passed, we entered a rolling country again similar to that mentioned above. A few hours' ride over a good road brought us to Bad Route Creek, a beautiful stream of excellent water frequented by ducks. Two green-winged teal were killed here, and proved to be a delightful addition to our larder. Buffalo were very scarce, those we saw being old bulls; but antelope, deer, and elk were seen constantly.

The road from Bad Route Creek winds through a long ravine up to a broad level plateau, where excellent grazing is to be found. The descent from this plateau to Clear Creek is easy. This latter creek is a well-timbered stream of sweet water.

From this valley we ascended to a plateau similar to the one we previously traversed, and finally descended to the valley of the Yellowstone, at the mouth of Spring Creek, after a journey of 32.3 miles.

From this point we followed the bottom-lands of the Yellowstone, only occasionally resorting to the bench to avoid a marsh or thick timber. Quite a number of wood-yards and ranches were passed, and this portion of the valley possessed somewhat of a civilized aspect. At Crane's Ranch, on Crane Creek, we halted for a short time to eat some fruit and melons. This ranch produces corn (both Dent and Ree grown without irrigation), sugar-corn, melons, tomatoes, beets, cabbage, turnips, lettuce, peas, and particularly fine potatoes and onions. Good oats are raised. I saw in several instances oats which, evidently dropped from a passing wagon, had sprung up and matured on the road. The hay, of course, is fine. Wheat can be profitably grown. The whole extent of bottom-lands is well adapted to farming. There is plenty of timber, and the creeks are running streams of clear sweet water. The benches and prairies above afford the best of grazing. It was only on this second overland trip that I was enabled to fully appreciate the value of the Yellowstone valley. Irrigation can be achieved without a great expenditure of either labor or money.

On September 9 we arrived at the ferry opposite Fort Buford, where we took the steamer for Bismarck.

The weather had been propitious and the journey was, all things considered, an interesting and enjoyable one. The odometer cart was driven the whole distance, the usual compass bearings and thermometric and barometric readings being taken. Sextant observations for time and latitude were taken whenever the weather permitted.

A summary table of altitudes, latitudes, longitudes, &c., is appended. A tracing of the map was forwarded to the Chief of Engineers on March 24, 1879, and the work has been incorporated in the map of Montana issued from this office.

The other field-work accomplished during the year was the rerunning of the northern and western boundaries of the Fort Snelling reservation, a detailed and elaborate survey of the portion of the Snelling reservation and occupied by the Seventh Infantry, a minute survey of the site of department headquarters buildings at the same post, and the laying out of the Snelling bridge highway across the reservation.

On the 2d of June, Topographical Assistant Wilson, accompanied by one private, left Saint Paul *en route* to Fort Custer to make surveys of the reservation of that post, of the small reservation near Fort C. F. Smith, and of the cemetery of Custer's battle-field. Should this work be finished in time to permit it, the Big Horn River will be meandered with transit and chain to connect with the survey of the Yellowstone River.

On June 18 I was ordered to inspect and report upon the burning coal-fields at Fort Stevenson. This duty was performed, I returning to Saint Paul on the 29th.

The office-work has consisted in computing and plotting the field-notes, revising and correcting the maps of Dakota and Montana, and such maps as were sent to this office for examination, in compiling information concerning the new posts in the department, in making numerous tracings and copies of reports for forwarding and for file in this office, in compiling tables of distances for the Paymaster-General, and in supplying such information and data as were called for.

Very respectfully, your obedient servant,

EDW. MAGUIRE,
*First Lieutenant, Corps of Engineers, U. S. A.*

The CHIEF OF ENGINEERS, U. S. A.

SUMMARY TABLE OF DAILY INSTRUMENTAL OBSERVATIONS, WITH DEDUCED ALTITUDES, LATITUDE, AND LONGITUDE OF EACH CAMP; DISTANCES TRAVELED, &C.

| Stations. | Date. | Start. | Arrive. | Barometer. | Thermometer. | Elevation, in feet. | Latitude. | Longitude. | Days' march, in miles. | Total distance, in miles. |
|---|---|---|---|---|---|---|---|---|---|---|
| Fort Keogh | Sept. 22, 1878 | 1.00 p. m. | ............ | 26.77 | 81° | 2,511.09 | 46° 23′ 11″.648 | 105° 56′ 53″.08 | ....... | ....... |
| Sunday Creek | Sept. 23, 1878 | 6.00 a. m. | 4 30 p. m. | 26.70 | 56° | 2,584.78 | ................ | ................ | 9.60 | 9.60 |
| Custer Creek | Sept. 24, 1878 | 5.50 a. m. | 3.00 p. m. | 26.90 | 38° | 2,391.09 | 46° 46′ 51″.29 | 105° 44′ 25″.65 | 24.60 | 34.20 |
| Branch Cedar Creek | Sept. 25, 1878 | 6.10 a. m. | 2.50 p. m. | 26.82 | 62° | 2,462.40 | 47° 00′ 11″.33 | 105° 26′ 27″.75 | 26.60 | 60.80 |
| Yellowstone River | Sept. 26, 1878 | 6.10 a. m. | 3.50 p. m. | 26.82 | 40° | 2,461.93 | 47° 06′ 08″.19 | 104° 48′ 28″.95 | 32.30 | 93.10 |
| Yellowstone River | Sept. 27, 1878 | 6.10 a. m. | 2.10 p m. | 26.85 | 42° | 2,437.49 | ................ | ................ | 29.05 | 122.15 |
| Near Yellowstone River | Sept. 28, 1878 | 6.20 a. m. | 2.30 p. m. | 26.95 | 62° | 2,350.42 | 47° 41′ 53″.96 | 104° 13′ 01″.65 | 29.20 | 151.35 |
| Missouri Ferry, opposite Fort Buford | Sept. 29, 1878 | ............ | 12.00 m. | 26.90 | 56° | 2,393.43 | ................ | ................ | 20.05 | 171.40 |

## SS 1.

## REPORT OF SURVEY OF THE MILITARY RESERVATION AT FORT KEOGH, MONTANA, BY TOPOGRAPHICAL ASSISTANT JULIUS J. DURAGE.

HEADQUARTERS DEPARTMENT OF DAKOTA,,
OFFICE OF CHIEF ENGINEER,
*Saint Paul, Minn.*, ——— ———.

SIR: In obedience to orders received from you and embodied in the following order:

[Special Orders No. 59.]

"HEADQUARTERS DEPARTMENT OF DAKOTA,
"*Saint Paul, Minn., May* 16, 1878.

* * * * * * *

"4. Lance Sergeant Julius J. Durage, general service, and Privates Thomas Culligan and Albert W. Turner, Company A, Battalion of Engineers, will proceed to Fort Keogh, Mont., and make the survey of the military reservation at that post, under the direction of the chief engineer officer of the department.

"The Quartermaster's Department will furnish the necessary transportation, and the Subsistence Department commutation of rations for Privates Culligan and Turner, for this journey, it being impracticable to carry subsistence in kind.

"By command of Brigadier-General Terry

"GEORGE D. RUGGLES,
"*Assistant Adjutant-General.*"

and in accordance with your special letter of instructions for guidance in operations, I have the honor to submit the following report:

I left Saint Paul, Minn., May 20, 1878, provided with the necessary instruments and material, and arrived at Fort Keogh, Mont., via Bismarck and Fort Buford, Dak., on the 4th of June, 1878. From that date up to the 14th of June I was debarred by continual rain and hazy nights from any active operations, spending the scant intervals of fair weather in taking a few astronomical observations and surveying the post and constructing a plot thereof. On the 16th of June I succeeded in determining the meridian and magnetic variation at the post, and on the 17th, provided with a complete working force, escort, and camp-equipage, I started for the mouth of the Tongue River, whereat, on the same evening, I succeeded in determining the primary azimuth for my survey. The waters of the Yellowstone and Tongue were at a very high stage, and there were no means of crossing the river, and I had to resort to a complicated method of triangulation to determine the intersection of the mid-channels. Having ascertained this point I established a bench-mark south of the Yellowstone and west of the Tongue near their confluence and situated 1,410.8 feet south of the initial point. In absence of stone I planted a post 8 feet long with charred butt, five feet in the ground, and marked: "Res. Ft. Keogh, B. M. U. S."

Unable to cross the Yellowstone I determined to start south to survey a base-line 10 miles long on which I could connect the boundary lines. This line proved to be a good check for my survey. The two men of the engineer detachment were employed, one in charge of the chainmen, keeping tallies; the other, assisting in taking bearings with the prismatic compass and noting the topography of the country passed over. From the benchmark the line runs through the Yellowstone Bottom until it reaches, at 11,944 feet, the foot-hills of the Yellowstone and Tongue divide, running out in a point here called Cantonment Butte. These bluffs are about 65 feet high, exhibiting a rough stony face. The ground is sandy loam impregnated with alkali, and containing a conglomerate of gravel and silicious fragments. The line ascends the crown of these bluffs, crossing numerous ravines, covered with large bowlders of friable sandstone.

I found myself surrounded by bad lands. Leaving the camp party to move up the Tongue, I started with pack-mules, the only mode to pass over this country, to survey the base-line further. There is no variety in this country; the same broken, rough surface covered with spare grass, impassable for wagons and difficult for animals. At 20,312 feet I found a spring on the summit of a moderate hill, which the hands of man have been improving, unquestionably Indians. The water was good. West of the line, dry drains lead towards the Yellowstone, east towards the Tongue. At 22,180 feet I had to cross a good sized hill; two large protrusions on the summit suggested the name of "Camelshump." Continuing through this broken country I arrived at the interior edge of these hills. They slope down into a beautiful grassy plain, about 1¼ miles long and the same width. But even this inviting sight was destined to disappoint our expectations for easier progress. Many furrows and gullies made our prog-

March 14, 1878, and is hereby announced for the information and government of all concerned, viz:

"Starting in mid-channel of the Yellowstone River, opposite the mouth of Tongue River, thence running due west 6 miles, thence due south about 10 miles to the southern boundary of the present temporary reservation, thence due east along said southern boundary till it reaches mid-channel of Tongue River, thence down said channel of Tongue River to the place of beginning, reserving a site for a ferry or bridge across Tongue River.

"All orders or parts of orders heretofore issued from any source whatever, conflicting with the provisions of this order, are hereby declared inoperative and void.

"By command of Brigadier-General Terry.

"GEO. D. RUGGLES,
*"Assistant Adjutant-General."*

Regarding the geological formation observed in this country I have the honor to report the following:

The geological formation is very uniform. The whole appearance shows the action of water. There are no signs of upheavals; the whole shows to be deposits of water acted again upon by water. The bottom lands are sandy, the shale being mixed with loam. They are very fertile, producing all species of excellent vegetables. These sandy deposits have a considerable depth, probably 12 to 15 feet. The lower strata of the elevated points are at some points laid bare, exhibiting conglomerate of clay and gravel, strongly impregnated with alkali; in some places thin layers of siliceous limestone, very brittle, in others a conglomerate sandstone, very porous, breaks to the surface. Above these layers I perceived deposits of clay and fragments of siliceous formation, the whole covered with about 2 feet of shale. North of the Yellowstone, in the bad lands near the northwest corner, the middle strata exhibit carboniferous limestone. The alluvial deposits exhibit a variety of colors, according to the material intermixed, white, yellow, and red being most prominent.

The botany of this country is very limited, there being but few representatives of trees, but a great variety of shrubs. The bottoms are covered with good grass, interspersed with sage-brush. The banks of the rivers are lined with high cottonwood and willow. There is some higher vegetation along some of the creeks. The very useful pine tree is only very sparsely represented, the principal district being about a mile south of the southern boundary and east of the Tongue River. The varieties observed may be classified as follows: White pine (Norway), cedar, American aspen, American elm, white ash, common juniper, hazel-nut, box elder, poison ivy, dogwood, white birch, choke-cherry, wild plum, gooseberry, wild red cherry, currant, raspberry, and blackberry.

The mammals are represented by the following species and varieties: Wild-cat, prairie wolf or cayoté, fox, weasel, skunk, badger, ground-squirrel, prairie-dog, gopher, prairie rat, jackass rabbit, sage-rabbit, red deer, white-tail deer, and antelope.

The following birds were observed: Wild duck and goose, sand-hill crane, curlew, robin, dipper, swallow, sparrow, finch, lark, blackbird, fly-catcher, woodpecker, owl, falcon, hawk, turkey-buzzard, pigeon, plover, gull, &c.

For determination of the altitude, I employed an aneroid barometer, regulated to the level of the sea at the United States signal-office at Bismarck, Dak. Three independent sets of observations were taken.

For the general magnetic variation at the post and establishing of the meridian, three sets of observations with a Stackpole transit and mean solar chronometer, Arnold & Dent, No. 1362, were used. The astronomical work was performed with help of sextant No. 6536, Spencer, Browning & Co., and sextant No. 1662, Stackpole & Bros.; artificial horizon and chronometers, Arnold & Dent, No. 1362, and Bond & Son, No. 202.

The results of these observations are:

Magnetic variation at post, 17° 37′ 30″.
Altitude, 2,511.09 feet above the level of the sea.
Longitude in arc, 105° 56′, 53′.08″.
Longitude in time, $7^h\ 3^m\ 47.538^s$.
Latitude, 46° 23′ 10.678″.

I am, sir, very respectfully, your obedient servant,

JULIUS J. DURAGE,
*Topographical Assistant.*

Lieut. EDWARD MAGUIRE,
*Corps of Engineers, U. S. A., Chief Engineer Department of Dakota.*

## S S 2.

### REPORT OF THE RECONNAISSANCE OF THE MOREAU OR OWL RIVER, DAKOTA, IN 1878, BY LIEUTENANT WILLIAM HOFFMAN, ELEVENTH UNITED STATES INFANTRY.

CHEYENNE AGENCY, DAKOTA, *December* 23, 1878.

SIR: I have the honor to submit the following report in connection with the duties assigned me by Special Orders No. 48, current series, Headquarters Cheyenne Agency, and letter of instruction dated Engineer's Office, Headquarters Department of Dakota, April 9, 1878.

The map called for is submitted at the same time; also field-notes, &c.

I started from this post on Sunday the 28th day of April, with a party of 25 enlisted men all told, and myself being the only officer with the detachment. My transportation consisted of three six-mule army wagons, and I was rationed to the 30th day of June, 1878.

The trip was made without any incident calling for special remark, excepting the fact that I happened to hit the rainy season, and that I was on this account impeded by bad and sometimes impassable roadway.

The rainy season lasted until June the 10th, up to which time I had made only one-third of my trip, and the result was that I had to work hard during the remaining twenty days, in order to get back to this post on the expiration of my rations. This I succeeded in doing, leaving no time to spare.

The Owl River country is practicable for campaigning purposes excepting in times of heavy rains. Then it would occasionally be impossible to move wagons, and frequently impossible to move artillery. Of water, grass, and wood there is plenty for ordinary military purposes, though the supply of the latter would soon be exhausted by any permanent military establishment.

In projecting marches through this country, it would be well always to consider the rainy season, which lasts from about the middle of April to the middle of June, as there is much "bad land" which is then impracticable.

#### GENERAL DESCRIPTION.

If a stream, that ordinarily could not be navigated by a ship's yawl for a distance of one-half mile above its mouth, is at all entitled to be called a "river," then this is properly the Owl River instead of the Moreau River, as the former is the original Indian name.

The stream runs through a rolling prairie country, with no timber beyond small skirts along water-courses, and occasional small groves in ravine heads. It has no mountains. The elevations amount generally to prairie-hills, eroded from an original level by the action of water. The presence of sulphur is everywhere apparent, and this, in connection with much limestone, gives the entire country, except the immediate mouth of the river, more or less of a "bad land" character; nevertheless there are some portions that would make excellent farms and stock ranches, and along the entire length of the stream the quality of the land varies through all the different grades from excellent to worthless. As a general fact the land is meager at the river head, and improves toward the mouth, where it is excellent.

#### HUSBANDRY.

The winters are severe, and but for this fact this would make a stock country from good to excellent, according to location. For a few years past the winters have been comparatively mild, and acclimated stock has lived through them without shelter. But the Indians tell of severe winters, in which men and animals perished, and I doubt if it would be prudent to attempt the raising of stock unless shelter is provided.

Though some portions of Montana, in even higher latitudes than this, are becoming prominent as stock districts, it must not be overlooked that the isothermal lines passing there are warmer than those passing here.

Many plateaus here are rich in gama-grass, while in the bottoms other good varieties are frequently abundant.

The land about the mouth of the river is very good and would make excellent farms, and here limited quantity of wood is the only drawback for farmers. The plateau at the mouth would make nicer farms than the bottoms, though some persons would prefer the latter. Indians who have tried farming near the mouth speak highly of the result, but these farms were on the Missouri rather than on the Owl River. The character of the country as regards husbandry may be called generally excellent from the mouth of Owl River to Virgin Creek.

From Virgin Creek to Little Moreau Creek the river bottom is generally bad, while beyond the breaks on the divides the land is generally good.

From Little Moreau Creek to Clay Bank Butte the bottom is generally bad, while beyond the breaks the land is generally fair.

From Clay Bank Butte to the mouth of Thunder Creek the immediate bottom, which is however small, is generally good, sometimes excellent, as at the mouth of Worthless Creek, while the uplands are generally bad, mostly entirely worthless.

From Thunder Creek to the neighborhood of the Slim Buttes the soil, river bottom and uplands alike, becomes gradually more meager and does not in any part promise well for farming. Some portion may serve as grazing grounds, while the larger portion is good for nothing.

DROUGHT.—The question of "seasons," as relates to rain, must remain open until observations have been made for a sufficient period of time. My information leads to the belief that rains cannot be depended on outside of the rainy season, and that severe drought during the hotter months is the rule.

WATER.—Indians say that this stream does not run in dry seasons, except at its extreme heads; but that it sinks, stands in holes, and seeps through the sand and gravel, &c., and that then the water, though fit for pressing needs, is poor and stinks. This is apparently caused by sulphate of lime, and probably applies mainly to the lower river, as at the stage-stand, on the main river, I was informed that the water runs a little in dry seasons; that the water is hard when high, and soft and better in taste when low. This advantage on the side of low water is probably due to filtration through the sand region in which this stage-stand is located.

There appear to be no well-defined springs tributary to this river. In some places, like at the extreme heads in the Slim Buttes, water is said to run the year round, yet here there are water-seeps rather than springs.

The river rises rapidly, according to the amount of rainfall, and remains up for considerable periods, proportionately to the same cause. From a small and almost dry bed, it may rise in one night to a rushing stream fifty yards wide and as many feet deep, while it may be unfordable during the entire rainy season.

WOOD.—Wood is comparatively scarce. All those portions of the river bottom, either subject to overflow or otherwise unfit for farms, might be utilized in the cultivation of cottonwood, and could thus be made to supply the immediate wants of a moderate farming population.

There is a considerable quantity of cottonwood, from 6 to 12 inches in diameter, near the mouth of the river, also some stunted oak and some ash.

Wood becomes less as one goes up the river, until it disappears entirely at about 15 miles from the heads; at those heads, however, that run from the Slim and Short Pine Buttes, wood is again found in the shape of a stunted pine only fit for fuel.

The different tributaries have more or less wood, generally in proportion to their sizes.

VEGETATION.—Many localities are rich in gama grass, while in the bottoms other good varieties are frequently abundant. Wild leek, many varieties of sage, carroway, and many other aromatic plants are indigenous to this locality and grow in such profusion that I am led to the conclusion that sulphur may very probably be the base of their odor.

Artichokes are also plentiful in spots. The Indian turnip *(Pomme Blanche)* is abundant on the heights from about the middle to the head of the river. This is a good substitute for bread being almost entirely of starch. The hull contains a yellow dye-stuff.

About the mouth of the river choke-cherries, fox-grapes, wild plumbs, black currants, and bull-berries grow. The latter is a fruit in size, color, and somewhat in taste resembling the red currant. It grows on large bushes, is acid and pleasant to the taste, and by its great abundance is quite an important fruit.

MINERALS.—Carbonate of lime and sulphur are the most prominent mineral features. Sulphate of lime is found in varying proportions wherever there are "bad-land" signs. Satin spar is the predominating sulphate and was found in largest quantities on Worthless Creek.

There are, in the Slim Buttes, beds of the bituminous coal common to this locality. It is associated with native sulphur in large proportion. There are present both brown and black coal, the brown overlying the black strata. This coal makes a tolerable fuel.

A coarse gray marble was first found on Red Water Creek, where it had evidently been the crown of a butte now washed down. This marble becomes more frequent as one approaches the Slim Buttes. These buttes are crowned with it, and under it is found a deposit of quartz sand which formed the sandstone found lower down. This sand is coarse and verging toward gravel.

A coarse reddish sandstone, not fully formed, through which specks of iron ore are disseminated, constitutes the crowns of buttes and hills in the neighborhood of Meadow, Red Water, and Little Moreau Creeks. The same stone, without the iron, is found further upstream.

Red Water Creek neighborhood is underlaid by a bed of lenticular iron ore. From Rabbit Creek to the mouth of the river strata of argillaceous shale are of frequent occurrence.

Submarine fossils are abundant even on the highest points, and are most frequent on the southern divide of Owl River.

But a few specimens, larger than a walnut, of granitic or quartzose rocks are found in the river drift.

No flint apparent at my crossing of Flint Rock Creek. Possibly it is to be found at the White Earth Mines, which are probably composed of an impure chalk-sand. All from Mountain Sheep Creek to Flint Rock Creek, on south side of river, inclined to be sandy. Sand-ledge Creek is probably the center of the sand district. It is serpentine, cutting perpendicular banks on alternate sides through a deep stratum of brown sand, slightly agglutinated, and having the appearance of brownstone ledges.

There is no gold apparent. I washed the river drift carefully throughout its entire length, and could not obtain a single "color." The great quantity of quartz sand in the Slim Buttes is plainly a water drift from some other locality, where any gold this quartz may have contained probably still remains.

GAME.—The game of this section consists of white and black tailed deer, antelopes in great numbers, prairie-chickens, some beaver, and muskrat. The buffalo no longer range here, and elk have been driven off, though an occasional one may still be found.

From the mouth of Thunder Creek up antelopes were so numerous that it required no special skill to kill more than we could use.

There are no fish in this river, except an occasional small catfish and a permanent gudgeon.

SCENERY.—There is but little remarkable scenery on this river. Only a few localities differ from the ordinary aspect presented by river-breaks through a bare rolling-prairie land. The Many Buttes, the Slim Buttes, and the view of the river as seen from the mouth of Worthless Creek, are the most prominent exceptions. The Many Buttes, seen on a misty morning, are impressive and resemble a city.

The river, as seen from the mouth of Worthless Creek, presents a picturesque view. It has here the character of a serpentine cañon, cutting its way deep through a mountain range. The steep land slides in the foreground, tinged by oxide of iron; the dark-green skirting of cottonwood, that winds into the distance with the river; the lighter shades of green in the various patches of vegetation, the yellowish Clay-bank Butte in the left center of the picture, all form harmony of outline and color highly pleasing to the eye.

The Slim Buttes, from a distance, appear as a range of mountains, indistinct, with dark-blue base and white outcroppings. As one approaches nearer, they appear covered with stubbles. This is the stunted pine growing on them. This sudden change of scenery, when coming from the prairies to the buttes, is impressive. In the one case we for months have had green, rolling, comparatively smooth, bare prairies, red land slides, and cottonwood skirts. In the other, we suddenly come upon the dark lead color given by distance; the rugged range, the snow-white spots, and pine growth. But a few steps over the boundary line, and we have a change that could not be expected ordinarily inside of hundreds of miles.

In going from one character of country to another it is usual for the scenic characteristics of one to blend gradually into those of the other, while in this case the change is abrupt.

The white color of the buttes is disintegrated limestone (gray marble in this case).

In the "breaks" of the buttes are many fantastic formations. Columns are found often vertical and 50 feet high. They are a composite of coarse, vitreous quartz, sand, and lime, slightly agglutinated.

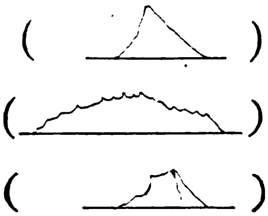
Some views are particularly good, principally the view of the North Pass. From a distance it resembles a brick, tile-covered village, and in the gap there are three columns resembling turreted castles, and as though built there to guard the pass.

The short pine hills are of the same general character as the Slim Buttes. The pine on either being but a sprinkling of scrub.

The "bad-land" slides from the mouth to Little Moreau Creek are gray to blackish in color. From Little Moreau Creek to Thunder Creek they are reddish; thence to Rabbit Creek they change to whitish; thence to the Slim Buttes iron oxide is again common.

### MISCELLANEOUS REMARKS.

Persons undertaking this country should be warned that generally the buttes are so much alike that one is apt to mistake their identity. These buttes as seen from different sides can only be recognized by taking them in connection with some other point. The conical, the jagged-topped, and the tent-shaped buttes are most difficult in this respect.



It is evident that large bodies of Indians have been located on this river, and that their latest camps were in the vicinity of Slave Buttes. There are large cottonwood stumps here, 4 feet in diameter, from which the trees have been chopped, and there being no more large trees the inference is that this was once the camping-ground of many Indians, who followed the growth of timber until it was all consumed (they destroy much by feeding their ponies on the bark). There is now only a young aftergrowth of trees here.

Fox Ridge is an abrupt wash on the south side of the divide, between the Owl and the Cheyenne Rivers, caused by sulphur action. It is " bad land," worthless and impassable for wagons when well wet.

It is the action of sulphur on rocks, soil, &c., causing disintegration, that supplies the mud held in suspension by the waters of this section, and from which the Missouri River derives its name. The soil appears to swell as though leavened with yeast, and it never becomes compact again. In dry weather it will hardly bear a pulling mule, and in rains the very hill-tops become bottomless quagmires.

### DERIVATION OF NAMES USED.

*Bastion Hill.* Named by myself from its resemblance to a bastion.

*Bear Creek.* The Indian name.

*Clay-bank Butte.* Named by myself from its appearance.

*Deer's Ears.* The Indian name derived from the outline appearance of the buttes.

*Elk Hills.* Named by myself from Indian tradition, which speaks of them as elk resorts.

*Flint Rock Butte.* The Indian name.

*Flint Rock Creek.* The Indian name.

*Fox Ridge.* The Indian name.

*Little Moreau Creek.* Called Little Moreau River on a previous survey; the term "river" cannot be properly applied.

*Meadow Creek.* Named by myself from the appearance of the land, as seen from my trail, through which it flows.

*Mountain Sheep Butte.* Named by myself from Indian reports which speak of it as the only locality on the river in which mountain sheep are still to be found.

*Mountain Sheep Creek.* Named by myself from its relative position to Mountain Sheep Butte.

*Owl River.* This is the original Indian name. It is sometimes called Moreau River.

*Patched Skin Buttes.* The Indian name.

*Rabbit Butte.* The Indian name.

*Rabbit Creek.* The Indian name.

*Red Earth Creek.* Named by myself from the pronounced color of the earth in spots.

*Sand-ledge Creek.* Named by myself from the sand ledges through which it runs.

*Short Pine Hills.* The accepted name, though not a literal translation of the Indian term.

*Slave Buttes.* The Indian name.

*Slim Buttes.* The accepted name. Thin Buttes being the translation of the Indian term.

*Thunder Buttes.* The Indian name.

*Thunder Creek.* The Indian name.

*Twin Buttes.* Name adopted from a previous survey.

*Virgin Buttes.* Named by myself on account of their proximity to Virgin Creek.

*Virgin Creek.* The Indian name.

*Wedge-tent Buttes.* Named by myself from its outline resemblance to a wedge tent.

*White Earth Mines.* The Indian name. Worthless Creek. Named by myself because all land lying on it appears to be absolutely worthless.

I have only given names where Indian or other names were unknown.

I am, sir, very respectfully, your obedient servant,

WILLIAM HOFFMAN,
*First Lieutenant, Eleventh Infantry.*

# S S 3.

## REPORT ON THE MAMMALS AND BIRDS OF THE GENERAL REGION OF THE BIG HORN RIVER AND MOUNTAINS OF MONTANA TERRITORY, BY CHARLES E. McCHESNEY, ACTING ASSISTANT SURGEON, UNITED STATES ARMY, 1878.

FORT SISSETON, DAKOTA.,
*November* 22, 1878.

SIR: I have the honor to transmit herewith my report on the mammals and birds of the Big Horn Region, Montana Territory.

As you are aware, I was ordered by the department commander on the 10th of July last to report in person to you at Fort Custer, Mont., for duty with exploration parties under your charge. I proceeded with all possible dispatch, *via* the Missouri and Yellowstone Rivers, to that post, where I arrived August 15, 1878, and pending your arrival I examined zoölogically to as great an extent as possible with the facilities at my command the region around Fort Custer, the result of which is embodied in the following pages.

On the 9th of September, having previously received a communication from you stating that you had been detained in Saint Paul by other duties so long that the exploration of the Big Horn Mountains would have to be deferred until another season, I left Fort Custer in obedience to orders assigning me to another field of duty. Thus less than a month was spent in examining the vicinity of Custer. This time was much too limited to examine thoroughly that extensive and interesting region.

Many species of birds that undoubtedly spend the spring and summer in the region had taken their departure before my arrival. I believe that instead of 100 species of birds here reported on much nearer 200 would be found by careful investigation to occur in this section of Montana, and the number of mammals would be increased by several species; so that the following report is by no means exhaustive of the subject.

The classification, &c., here followed is in strict accordance with the standard works of Dr. Elliott Coues, U. S. A., so far as his publications have been available.

I would respectfully recommend, in case an expedition is to be organized to examine this country during the coming year, that the zoölogist and botanist be at Fort Custer, fully equipped and ready to take the field, by the 1st of June, as otherwise much that is of great scientific interest would be lost by a later start.

I cannot close this letter without expressing my thanks to the officers stationed at Fort Custer, who did so much to render my stay at that post both profitable and pleasant.

I am, sir, very respectfully, your obedient servant,

CHARLES E. McCHESNEY,
*Acting Assistant Surgeon, U. S. A.*

Lieut. EDWARD MAGUIRE,
*Corps of Engineers, U. S. A., Chief Engineer, Department of Dakota.*

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# CHAPTER I.

# MAMMALS.

## MONODELPHIA EDUCABILIA.

## FERÆ.

### FAMILY FELIDÆ.

### GENUS FELIS, Linn.

**FELIS CONCOLOR**, Linn.—*Rocky Mountain Lion.*

This lion is found in the Big Horn Mountains in small numbers. I was shown, at Fort Custer, Mont., the skin of one that had been killed in January, 1878, in the Big Horn Mountains; the skin, which was in the possession of Lieutenant-Colonel Buell, Eleventh Infantry, indicated that the animal had been an average one in size.

This lion has also been found in other parts of Montana, in considerable numbers, within the past year or two.

### GENUS LYNX, Raf.

LYNX CANADENSIS (Desm.), Raf.—*Canada Lynx.*

Was first observed crossing the Yellowstone River, above Fort Keogh, Mont., August 10, 1878.

At Fort Custer, Mont., I was shown a skin of this lynx, belonging to Lieutenant Rawolle, Second Cavalry, that had been killed about 40 miles from that post on the Little Horn River, in February, 1878.

This lynx is quite common in the mountains and foot-hills along both the Big and Little Horn Rivers, a few miles from Fort Custer, Mont.

The skin in Lieutenant Rawolle's possession I refer to *Lynx canadensis* rather than to *L. rufus;* although it is not a typical *L. canadensis*, still it comes nearer that species, presenting, however, some of the characteristics of the *L. rufus.* The skin may have been from a slightly immature specimen, but it is not improbable that there is a variety of *L. canadensis* inhabiting the region of the Big Horn Mountains.

Col. A. G. Brackett, of the Second United States Cavalry, to whom I am under many obligations for valuable assistance rendered me at Fort Custer, informs me that he thinks there may be a third lynx inhabiting the mountainous region under consideration, as he has there seen a small lynx which he believes to be different from any that have been described by authors. Should this prove to be the case it will be a very interesting discovery. To this point I will give special attention should it be my fortune to again visit the region around Fort Custer.

LYNX RUFUS (Gm.), Raf.—*Bay Lynx; Wild Cat.*

I did not meet with the wild cat during any part of my travels, but it is said to be not uncommon throughout the general region visited, especially the mountainous portions of the Big and Little Horn Rivers.

## FAMILY CANIDÆ.

### GENUS CANIS, Lynx.

CANIS LUPUS OCCIDENTALIS, Cs. and Yar.—*American Timber Wolf.*

I did not myself observe this wolf, but Captain Read, of the Eleventh Infantry, informed me that he had seen it along the Yellowstone River, near Terry's Landing, as also in the immediate vicinity of Fort Custer.

I saw several skins of the American timber wolf at a trading store at Baker's battle-field, on the Yellowstone River, about 40 miles from Fort Custer, and was there informed that this wolf was quite common in that locality, and that the skins shown me were of animals killed in that immediate vicinity.

CANIS LATRANS, Say.—*Prairie Wolf; Coyote.*

Is quite common in the vicinity of Fort Custer, along both the Big and Little Horn Rivers. I also saw several while crossing from Fort Custer to Fort Ellis, Mont., in September.

Unless seriously threatened, the prairie wolf does not seem to be particularly afraid of man. I observed that they would run to a safe distance, perhaps 800 or 1,000 yards, and generally stop and deliberately view the intruder, but they did not seem anxious for a much closer acquaintance, as they would scamper off if approached a little nearer.

The prairie wolf undoubtedly does his full share in the way of destruction to the rabbits and ground squirrels, upon which, as well as grouse also, it frequently makes a dainty meal.

### GENUS VULPES.

VULPES VULGARIS PENNSYLVANICUS (Bodd.), Coues.—*American Red Fox.*

Is found in small numbers in the vicinity of Fort Custer, Mont., and is doubtless common throughout most of the Big Horn region.

The variety of the red fox known as the *crossed fox* is represented to a small extent in this region. I was shown a very fine skin of this fox, belonging to Lieutenant Huntington, Second Cavalry, that had been killed on the Little Horn River, about 30 miles above Fort Custer, in October, 1877.

VULPES MACRURUS (Bodd.).—*Large Prairie Fox.*

Was not observed on the trip, but is known to inhabit the general region under consideration.

**VULPES VELOX**, Aud. and Bach.—*Swift; Kit Fox.*

Occurs in considerable numbers along the Yellowstone River, and is quite common in the vicinity of Fort Custer, Mont., along the Big and Little Horn Rivers.

## FAMILY MUSTELIDÆ.

### SUBFAMILY MARTINÆ.

### GENUS PUTORIUS, Cuvier.

**PUTORIUS LONGICAUDA** (Rich.).—*Long-tailed Ermine.*

Are found in considerable numbers in the vicinity of Fort Custer. I observed them in the pines on a spur of the Big Horn Mountains, August 30. Are known to occur on the Little Horn River above Fort Custer.

*Measurements of specimens.*

| | No. 445 | No. 475 |
|---|---|---|
| | ♂ | ♂ |
| From tip of nose to eye | 0.78 | 0.67 |
| From tip of nose to ear | 1.63 | 1.45 |
| From tip of nose to occiput | 2.30 | 2.11 |
| From tip of nose to tail | 10.40 | 9.10 |
| Tail to end of vertebræ | 7.50 | 4.50* |
| Length of fore foot | 1.47 | 1.19 |
| Length of hind foot | 1.92 | 1.75 |
| Width of palms | 0.52 | 0.44 |
| Longest fore claw | 0.43 | .......... |
| Tail black tipped | 2.40 | .......... |
| Height of ears | .......... | 0.62 |

* Tail partly lost.

These two specimens present additional proof of the correctness of Dr. Coues's views that this ermine should be compared with *P. brasiliensis var. frenatus*, and not with *Putorius erminea.*

**PUTORIUS (CYNOMYONAX) NIGRIPES** (Aud. and Bach.), Coues.—*American Black-footed Ferret.*

Col. A. G. Brackett, United States Army, in a letter dated Fort Custer, Mont., April 11, 1879, kindly informs me that he has a black-footed ferret, which was caught by some Crow Indians on the Little Big Horn, March 24, 1879. I believe this is the first specimen of this little-known mammal taken in that section of Montana.—C. E. McC., Fort Sisseton, May 13, 1879.

**PUTORIUS VISON** (Schreb.), Rich.—*Mink.*

Evidences of the presence of the little brown mink are to be seen along the Little Horn River near Fort Custer, Mont., and specimens have been taken along the Stinking Water.

The brown mink, however, is not common in the clear and cold mountain streams of this region, and I doubt if it be such waters that this animal prefers at all.

The mink is said to be a deadly enemy of the muskrat, sometimes entering a house and destroying all the inmates, who make little of no resistance; at other times it will enter a lake inhabited by muskrats and in a short time cause them to abandon it.

### SUBFAMILY MEPHITINÆ.

### GENUS MEPHITIS, Cuv.

**MEPHITIS MEPHITICA** (Shaw), Bd.—*American Skunk.*

Was found to occur in numbers all along the Yellowstone River from Fort Buford to near Fort Ellis; was common at Fort Custer and along the Big and Little Horn Rivers, and in fact throughout the entire region visited.

The bite of the skunk, so fatal in more southern latitudes, is almost unknown in the northern regions. I have never (in a residence of over eleven years in Dakota and Montana) known of a single case of skunk-bite to occur in either Territory, although in most of the localities that I have visited the skunk has been found to be resident in numbers. It is probably a case parallel with that of the rattlesnake, which does not strike near as often nor is its bite as venomous in cold as in a warm climate.

### SUBFAMILY MELINÆ.

#### GENUS TAXIDEA, Waterhouse.

TAXIDEA AMERICANA (Bodd.), Bd.—*American Badger.*

Was quite common at Fort Custer when the post was established in 1877, and still occurs in considerable numbers in that vicinity. Is found along the Rosebud and Clark's Fork in numbers.

The badger displays a considerable amount of courage when occasion requires, sometimes even turning on man; and I have seen more than one person beat a precipitate retreat under such circumstances.

### SUBFAMILY LUTRINÆ.

#### GENUS LUTRA.

LUTRA CANADENSIS (Turton), Cuv.—*North American Otter.*

Occurs in small numbers on the Little Horn River near Fort Custer, Mont., as probably on the Big Horn also. Is found in numbers on Grass Lodge Creek about 30 miles from Fort Custer, Mont.

### FAMILY PROCYONIDÆ.

#### GENUS PROCYON, Storr.

PROCYON LOTOR (Linn.), Storr.—*Raccoon.*

Is occasionally seen along the Missouri River, but I did not meet with it along either the Yellowstone or Big Horn Rivers, and I doubt whether it ascends as high as these rivers.

### FAMILY URSIDÆ.

#### GENUS URSUS, Linn

URSUS ARCTOS horribilis (Ord.), Coues and Yar.—*Grizzly-Bear.*

Colonel Brackett showed me at Fort Custer the skin of one that had been killed in December, 1877, near Little Horn River, Montana.

Is common in the Bighorn Mountains.

The grizzly bear is quite fond of the wild plums and other fruit of the mountains in season, and he knows when the season for them has arrived as well as man does; when feeding he does not like interruption in the shape of man's intrusion, which he will terribly resent if the person is not well on his guard. I found but few hunters who cared to have anything to do with the grizzly, and, as for myself, I am free to confess that I am no aspirant for bear honors.

URSUS AMERICANUS, Pall.—*Black Bear.*

Tracks of a young black bear were seen on the right bank of the Yellowstone River near Froze-to-death (above Fort Keogh), August 11.

Is quite common at this time along all the streams running into the Big and Little Horn Rivers near Fort Custer, Mont., where it is known as the "Cinnamon" bear. Occurs throughout the Bighorn Mountains in numbers.

Variety *cinnamoneus* is represented very largely in this region.

I saw robes at Baker's battle-field showing almost all variations, from the extreme black to the pale cinnamon color, that had been taken in the Bighorn Mountains.

While the black bear is not nearly as ferocious as the grizzly, still he will make a desperate fight when occasion requires; such, for instance, as when he has been slightly wounded and his enemy is within reach.

### FAMILY BASSARIDIDÆ.

#### GENUS BASSARIS, Licht.

BASSARIS ASTUTA.—*Civet Cat.*

Was seen on Snake River two years ago by Scott Bonham, an old and experienced hunter and trapper in the Bighorn region.

Of the existence of this cat in various parts of Montana, some ten or eleven years ago, I have been assured by many miners and others who had observed them in a state of semi-domestication in several of the mining camps.

## UNGULATA.

### FAMILY BOVIDÆ.

#### GENUS BOS, Linn.

**BOS AMERICANUS, Gm.**—*Buffalo.*

The first buffalo seen on the trip was above Fort Keogh, Mont., August 10. On August 13 four or five were killed at Terry's Landing, on the Yellowstone, by members of Captain Conrad's company, Eleventh Infantry. Were abundant about Fort Custer, and were killed within the boundaries of the post twice during 1878.

The Crow Indians are now killing a great many buffalo, and Blackfoot's band, numbering about 30 lodges, which I saw encamped on the banks of the Yellowstone River some distance below the mouth of the Bighorn, killed over 400 during the months of June and July, 1878. I saw the bones of several lying on the prairie between Terry's Landing and Fort Custer.

The northern band of buffalo is rapidly being exterminated, and this not so much by the Indian as by the white men who inhabit and pass through the country through which they roam. I have seen the most reckless slaughter of buffalo by white men, when they had no use for and could not even secure a single one of them; this principally by a class of people who travel on the steamboats plying between Bismarck and Fort Benton, on the Missouri River, most of whom are sane enough on all other points, but seem to think they must endeavor to kill every buffalo within sight, and many a poor animal is wounded and left to drag along a miserable existence until their wounds prove fatal. This class of people need the application of the law, which if stringently applied in a few instances would do much to relieve the present state of affairs, but time and distance from officers of the law both serve to prevent such merited punishment. I am pleased to note, however, of late, a growing disposition on the part of captains of boats to put a stop to the indiscriminate shooting from their vessels.

The Indian understands and heeds too the importance to him of preserving and increasing the buffalo, and there is no reckless slaughter on his part. If all the meat secured on a hunt cannot be used in its fresh state it is preserved by drying, and comes in play at a future day; and then, too, the males of a herd only are killed as a rule.

The years the Indians can now exist in their wild state are numbered by the supply of buffalo, and there can be no doubt but that the number of these is being rapidly reduced each year. The immense herds we used to see and hear of on the Missouri River some ten years ago are now unknown, and this very circumstance, more probably than anything else, will bring the Indian in a short time to cultivate the soil, which, of course, he can only do when on terms of friendship, or at least at peace, with the whites.

### FAMILY OVIDÆ.

#### GENUS APLOCERUS, H. Smith.

**APLOCERUS COLUMBIANUS (Desmont), Coues.**—*Rocky Mountain Goat.*

On Pryor's Fork of the Yellowstone River last October (1877), and about 50 miles from Fort Custer, Mont., a herd, numbering 15 or 20, was seen by Corporal Irwin, Second Calvary, who succeeded in securing one.

The Rocky Mountain goat is not, however, of very common occurrence throughout the Bighorn region.

#### GENUS OVIS, Linn.

**OVIS MONTANA, Cuv.**—*Rocky Mountain Sheep.*

A flock containing 8 or 10 animals was seen on the cliffs opposite Sherman, on the Yellowstone River, June 6, 1878, by Colonel Brackett, who informs me that they are common in the Big Horn Mountains.

### FAMILY ANTILOCAPRIDÆ.

#### GENUS ANTILOCAPRA, Ord.

**ANTILOCAPRA AMERICANA, Ord.**—*Prong-horn Antelope.*

Is common throughout the region traveled.

An interesting account of the shedding of the horns of this antelope was kindly furnished me by Captain Read, Eleventh United States Infantry, who observed it near Fort Custer, Mont., in December, 1877, in a spur of the Big Horn Mountains.

The first occurrence was about December 12. He had shot an antelope that had shed one of its horns, apparently but a very short time before being killed, and the other horn came off when he took hold of it and without the exercise of any force.

On a subsequent occasion, during the same month, both horns of an antelope he had killed were removed by the use of very little force, showing that they were about to be shed by the animal.

Upon careful inquiry among hunters and mountain men, I found several who had personal knowledge of the shedding of the horns of the prong-horn antelope, and all agreed that the event took place in December, while many men with good opportunities for observing in such cases seemed somewhat surprised at my asking them if they ever knew of an instance of this kind, replying in the negative, and accompanying it with a look that seemed to say they thought me a little "green" in such matters, and would inform me that the deer was in the habit of doing such things but not the antelope.

Captain Read's account is interesting from the fact that the entire horn was cast off: the shedding of the velvet has been, of course, long known, but this is the first instance recorded, so far as I am aware, in which the casting off of the entire horn has been seen by a careful and thoroughly competent observer.

### FAMILY CERVIDÆ.

#### GENUS CERVUS, Linn.

**CERVUS CANADENSIS**, Erxl.—*American Elk.*

Is quite common in the Big Horn Mountains; a band of about 50 was seen on a small creek running into the Big Horn River about 15 miles from Fort Custer, August 8, 1878; the band consisted principally of cows and calves, as is usual at this season of the year.

#### GENUS CARIACUS, Gray.

**CARIACUS VIRGINIANUS** (Bodd). Gray.—*White-tailed Deer.*

Common along the Yellowstone River, and through the Big Horn region. I saw a very handsome fawn at Fort Custer, Mont., that had been brought into that post by Crow Indians in June 1878.

**CARIACUS MACROTIS** (Say), Gray.—*Black-tailed Deer.*

Common on the Yellowstone River, as also in the vicinity of Fort Custer and along the Big Horn Mountains.

I suppose the question I have of late seen argued pro and con in the columns of "Forest and Stream," as to whether the deer sheds his horns, may be considered as settled in the affirmative. That such is the case I have been assured by many good observers, and can personally bear testimony to the fact.

# MONODELPHIA INEDUCABILIA.

## CHIROPTERA.

### FAMILY VESPERTILIONIDÆ.

#### GENUS CORYNORHINUS, Allen.

**CORYNORHINUS MACROTIS** (Le C.), Allen.—*Big-eared Bat.*

A single specimen was killed in an officer's quarters at Fort Custer, about June 15, 1878, and was identified by Colonel Brackett, as *C. macrotis.*

I saw on August 28 and 29, in camp on a spur of the Big Horn Mountains, several bats, but none were secured. Accepting however Colonel Brackett's identification, I refer them to *C. macrotis*, although it is not at all improbable that more than one species of bat occur in this region.

## INSECTIVORA.

### FAMILY SORICIDÆ.

#### GENUS SOREX, Linn.

**SOREX COOPERI**, Bach.—*Cooper's Shrew.*

Is not known to occur in the region traveled.

At Fort Sisseton, Dak., where I have been engaged in collecting during the greater part of three seasons past, Cooper's shrew is quite common, and as the following measurements have not yet been published, I include them in this report, with certain deductions therefrom and comparison with *Sorex pachyurus* to be found under the head of that species.

The following measurements are of specimens taken at Fort Sisseton, Dak.,

| No. | Sex. | Date of collecting. | From tip of nose to— | | | | Tail to end of vertebræ. | Length of— | | Width of palms. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Eye. | Ear. | Occiput. | Tail. | | Fore foot. | Hind foot. | |
| 198 | ♀ | August 5, 1877 ....... | 0.30 | 0.56 | 0.78 | 1.90 | 1.50 | 0.24 | 0.37 | ........ |
| 203 | ♀ | August 25, 1877 ....... | 0.29 | 0.53 | 0.75 | 2.00 | 1.60 | 0.20 | 0.39 | ........ |
| 227 | ♀ | September 22, 1877... | 0.25 | 0.54 | 0.72 | 1.90 | 1.40 | 0.22 | 0.38 | 0.08 |
| 359 | ♀ | October 26, 1877....... | 0.31 | 0.56 | 0.79 | 2.10 | 1.50 | 0.25 | 0.42 | ........ |
| 360 | ♀ | October 26, 1877....... | 0.31 | 0.58 | 0.81 | 2.05 | 1.50 | 0.27 | 0.43 | ........ |
| 361 | ♂ | October 26, 1877....... | 0.30 | 0.57 | 0.77 | 2.10 | 1.50 | 0.25 | 0.40 | ........ |
| 373 | × | November 13, 1877.... | 0.30 | 0.50 | 0.73 | 2.00 | 1.60 | 0.25 | 0.44 | ........ |
| 374 | ♂ | November 14, 1877.... | 0.32 | 0.60 | 0.81 | 2.00 | 1.60 | 0.25 | 0.49 | ........ |
| 377 | ♀ | November 19, 1877.... | 0.33 | 0.66 | 0.83 | 2.15 | 1.60 | 0.25 | 0.44 | ........ |
| 383 | ♀ | December 1, 1877..... | 0.35 | 0.70 | 0.80 | 2.25 | 1.65 | 0.25 | 0.45 | ........ |
| 386 | ♀ | December 4, 1877..... | 0.30 | 0.65 | 0.76 | 1.90 | 1.10 | 0.25 | 0.41 | ........ |
| 387 | ♂ | December 4, 1877..... | 0.25 | 0.61 | 0.74 | 1.95 | 1.60 | 0.27 | 0.42 | ........ |
| 388 | ♂ | December 4, 1877..... | 0.31 | 0.55 | 0.81 | 2.15 | 1.95 | 0.27 | 0.46 | ........ |
| 390 | ♀ | December 10, 1877.... | 0.32 | 0.68 | 0.84 | 2.10 | 1.70 | 0.28 | 0.43 | ........ |
| 391 | ♂ | December 10, 1877.... | 0.30 | 0.65 | 0.73 | 2.10 | 1.40 | 0.26 | 0.41 | ........ |
| 393 | ♂ | December 18, 1877.... | 0.29 | 0.59 | 0.78 | 2.05 | 1.70 | 0.25 | 0.41 | ........ |
| 394 | ♂ | December 18, 1877.... | 0.32 | 0.61 | 0.76 | 1.95 | 1.70 | 0.25 | 0.43 | ........ |
| 395 | ♂ | December 18, 1877.... | 0.31 | 0.62 | 0.78 | 2.00 | 1.60 | 0.25 | 0.42 | ........ |
| 396 | ♀ | December 18, 1877.... | 0.36 | 0.65 | 0.80 | 2.05 | 1.65 | 0.26 | 0.45 | ........ |
| 397 | ♀ | December 18, 1877.... | 0.34 | 0.59 | 0.77 | 2.05 | 1.70 | 0.25 | 0.42 | ........ |
| 399 | ♂ | December 21, 1877.... | 0.35 | 0.68 | 0.77 | 2.10 | 1.70 | 0.24 | 0.42 | ........ |
| 400 | ♂ | December 21, 1877.... | 0.25 | 0.61 | 0.75 | 1.95 | 1.45 | 0.24 | 0.41 | ........ |
| 401 | ♂ | December 22, 1877.... | 0.30 | 0.59 | 0.71 | 2.10 | 1.70 | 0.24 | 0.45 | ........ |
| 402 | ♂ | December 22, 1877.... | 0.35 | 0.74 | 0.84 | 2.05 | 1.90 | 0.29 | 0.47 | ........ |
| 403 | ♀ | December 24, 1877.... | 0.34 | 0.68 | 0.78 | 2.10 | 1.55 | 0.28 | 0.44 | ........ |
| 406 | ♀ | February 16, 1878.... | 0.37 | 0.74 | 0.83 | 2.10 | 1.65 | 0.27 | 0.44 | ........ |
| 407 | ♀ | February 16, 1878.... | 0.35 | 0.69 | 0.80 | 2.00 | 1.70 | 0.27 | 0.47 | ........ |
| 408 | ♂ | February 21, 1878.... | 0.33 | 0.60 | 0.74 | 2.25 | 1.70 | 0.25 | 0.42 | ........ |
| 409 | ♀ | February 21, 1878.... | 0.33 | 0.65 | 0.80 | 2.20 | 1.55 | 0.26 | 0.44 | ........ |
| 410 | ♀ | February 21, 1878.... | 0.37 | 0.70 | 0.83 | 2.00 | 1.80 | 0.27 | 0.47 | ........ |
| 411 | ♂ | February 21, 1878.... | 0.33 | 0.60 | 0.78 | 2.00 | 1.50 | 0.25 | 0.43 | ........ |
| 412 | ♂ | February 25, 1878.... | 0.32 | 0.62 | 0.75 | 2.00 | 1.60 | 0.27 | 0.46 | ........ |
| 413 | ♀ | March 1, 1878....... | ........ | ........ | ........ | 2.00 | 1.70 | 0.27 | 0.46 | ........ |
| 415 | ♀ | March 4, 1878....... | 0.34 | 0.65 | 0.76 | 2.00 | 1.70 | 0.27 | 0.47 | 0.10 |
| 418 | ♀ | March 13, 1878....... | 0.38 | 0.68 | 0.82 | 2.10 | 1.75 | 0.27 | 0.47 | 0.10 |
| 420 | ♂ | March 14, 1878....... | 0.35 | 0.68 | 0.85 | 2.00 | 1.55 | 0.27 | 0.45 | 0.10 |
| 426 | ♂ | March 15, 1878....... | 0.35 | 0.65 | 0.84 | 2.10 | 1.70 | 0.25 | 0.45 | ........ |
| 429 | × | March 21, 1878....... | 0.31 | 0.67 | 0.82 | 1.85 | 1.60 | 0.26 | 0.47 | 0.10 |
| 430 | ♂ | March 21, 1878....... | 0.27 | 0.57 | 0.74 | 1.90 | 1.45 | 0.24 | 0.41 | 0.09 |
| 431 | ♂ | March 21, 1878....... | 0.30 | 0.58 | 0.78 | 2.05 | 1.60 | 0.27 | 0.45 | 0.10 |
| 432 | ♂ | March 21, 1878....... | 0.33 | 0.53 | 0.78 | 2.00 | 1.60 | 0.25 | 0.43 | 0.10 |
| 433 | ♂ | March 21, 1878....... | 0.35 | 0.65 | 0.82 | 2.05 | 1.55 | 0.26 | 0.45 | 0.10 |
| 436 | ♀ | March 22, 1878....... | 0.32 | 0.67 | 0.78 | 2.10 | 1.70 | 0.26 | 0.45 | 0.10 |
| 437 | ♂ | March 22, 1878....... | 0.31 | 0.63 | 0.80 | 2.10 | 1.70 | 0.26 | 0.45 | 0.10 |
| 442 | ♂ | March 26, 1878....... | 0.32 | 0.60 | 0.81 | 2.10 | 1.50 | 0.25 | 0.41 | ........ |
| 443 | ♂ | March 26, 1878....... | 0.33 | 0.55 | 0.82 | 2.10 | 1.65 | 0.25 | 0.46 | ........ |
| 447 | ♂ | March 26, 1878 ....... | 0.35 | 0.68 | 0.82 | 2.15 | 1.85 | 0.25 | 0.46 | 0.10 |
| 456 | ♀ | March 27, 1878 ....... | 0.30 | 0.50 | 0.78 | 1.90 | 1.50 | 0.27 | 0.43 | 0.10 |
| 457 | ♂ | March 27, 1878 ....... | 0.33 | 0.55 | 0.78 | 1.90 | 1.50 | 0.27 | 0.43 | 0.09 |
| 458 | ♂ | March 28, 1878 ....... | 0.29 | 0.55 | 0.78 | 1.95 | 1.45 | 0.25 | 0.45 | 0.09 |
| 469 | ♂ | March 30, 1878 ....... | 0.30 | 0.61 | 0.80 | 2.00 | 1.55 | 0.25 | 0.45 | 0.09 |
| 470 | ♀ | March 30, 1878 ....... | 0.25 | 0.60 | 0.78 | 2.05 | 1.45 | 0.27 | 0.44 | 0.09 |
| 473 | ♂ | April 4, 1878 ......... | 0.27 | 0.60 | 0.81 | 2.00 | 1.45 | 0.28 | 0.46 | 0.10 |
| 474 | ♂ | April 5, 1878 ......... | 0.31 | 0.58 | 0.81 | 1.80 | 1.50 | 0.28 | 0.44 | 0.08 |
| 476 | ♂ | April 8, 1878 ......... | 0.30 | 0.66 | 0.80 | 1.95 | 1.50 | 0.25 | 0.44 | 0.08 |
| 477 | ♂ | April 13, 1878 ........ | 0.31 | 0.61 | 0.80 | 2.15 | 1.65 | 0.27 | 0.46 | 0.08 |
| 478 | ♂ | May 16, 1878 ......... | 0.28 | 0.60 | 0.78 | 2.15 | 1.45 | 0.25 | 0.44 | 0.09 |
| 479 | ♂ | May 16, 1878 ......... | 0.30 | 0.63 | 0.80 | 2.15 | 1.50 | 0.26 | 0.45 | 0.09 |
| 481 | ♂ | May 22, 1878 ......... | 0.30 | 0.63 | 0.80 | 2.20 | 1.60 | 0.26 | 0.45 | 0.09 |
| 482 | ♀ | May 26, 1878 ......... | 0.34 | 0.62 | 0.84 | 1.80 | 1.60 | 0.28 | 0.42 | 0.00 |
| 493 | ♀ | June 30, 1878......... | 0.31 | 0.64 | 0.82 | 2.00 | 1.55 | 0.25 | 0.43 | 0.09 |
| 583 | × 9 ♀ | July 11, 1878......... | 0.31 | 0.55 | 0.78 | 1.60 | 1.50 | 0.27 | 0.40 | 0.07 |
| 584 | × 9 ♀ | July 12, 1878......... | 0.32 | 0.62 | 0.78 | 1.90 | 1.45 | 0.26 | 0.41 | 0.07 |
| | | From the above we obtain: | | | | | | | | |
| | | Mean of thirty-five ♂. | 0.31 | 0.61 | 0.81 | 2.04 | 1.59 | 0.26 | 0.44 | 0.09 |
| | | Minimum of thirty-five ♂ ............. | 0.25 | 0.55 | 0.71 | 1.80 | 1.40 | 0.24 | 0.40 | 0.08 |

| No. | Sex. | Date of collecting. | From tip of nose to— | | | | Tail to end of vertebræ. | Length of— | | Width of palms. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Eye. | Ear. | Occiput. | Tail. | | Fore foot. | Hind foot. | |
| | | Maximum of thirty-five ♂ | 0.35 | 0.74 | 0.85 | 2.25 | 1.95 | 0.29 | 0.49 | 0.10 |
| | | Mean of twenty-three ♀ | 0.32 | 0.63 | 0.80 | 2.03 | 1.58 | 0.26 | 0.43 | 0.09 |
| | | Minimum of twenty-three ♀ | 0.25 | 0.53 | 0.72 | 1.90 | 1.10 | 0.20 | 0.37 | 0.06 |
| | | Maximum of twenty-three ♀ | 0.38 | 0.74 | 0.84 | 2.25 | 1.80 | 0.28 | 0.47 | 0.10 |
| | | Mean of 58 specimens | 0.31 | 0.62 | 0.80 | 2.03 | 1.58 | 0.26 | 0.43 | 0.09 |

1. Specimens Nos. 373, 413, 429, 583, and 584 have been excluded from these results for obvious reasons.
2. Seventeen specimens.
3. Eight specimens.
4. Twenty-five specimecs.

The above measurements were carefully taken in the flesh by myself, and agree with results obtained by other collectors.

The winter of 1877–'78 was an unusually mild one at Fort Sisseton, and, in consequence, the collecting of small mammals could be successfully pursued, and many specimens of the rarer ones were taken, with a comparatively large number of *Sorex Cooperi*, the capture of which, especially during the winter months, is ordinarily attended with considerable difficulty.

I have had almost no success in capturing this little animal during the summer; the few specimens secured at this season have been taken alive, and endeavors were made to keep them in captivity, in order to observe certain important and unknown physiological conditions, and although I tried every plan I could think of, every one died within two days.

Of the habits of Cooper's shrew I am unable to say anything positive at present. From my observation, however, I believe the periods of gestation and lactation to be much longer than among the species of the nearest allied family. The little animal appears to be unable to take care of itself when in the least difficulty. Last summer several pits were being dug at the post, and every morning two or three Cooper's shrews were found at the bottom of them, running from side to side, but they never attempted to climb out or burrow, and from the latter circumstance I surmise their underground homes are not dug to any depth.

SOREX PACHYURUS.—*Shrew.*

Considering *S. pachyurus* a perfectly valid species, I include below a list of measurements of six specimens that I am unable to refer to any other species of Sorex. These specimens were taken at Fort Sisseton, Dak. The little mammal is not known to occur in the region of the Big Horn, although I suspect that the range of several species of shrews is much more extended than is now known.

| Number. | Sex. | Date of collecting. | From tip of nose to— | | | | Tail to end of vertebræ. | Length of— | | Width of palms. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Eye. | Ear. | Occiput. | Tail. | | Fore foot. | Hind foot. | |
| 384 | × | December 1, 1877 | 0.40 | 0.70 | 0.96 | 2.60 | 1.65 | 0.36 | 0.52 | ........ |
| 392 | × | December 15, 1877 | 0.38 | 0.80 | 0.96 | 2.75 | 1.90 | 0.34 | 0.52 | ........ |
| 404 | ♂ | December 24, 1877 | 0.40 | 0.73 | 1.01 | 2.55 | 1.60 | 0.36 | 0.52 | 0.14 |
| 416 | ♂ | March 5, 1878 | 0.42 | 0.72 | 0.97 | 2.50 | 1.85 | 0.34 | 0.55 | 0.12 |
| 410 | ♂ | March 14, 1878 | 0.39 | 0.69 | 0.95 | 2.50 | 1.90 | 0.36 | 0.54 | 0.12 |
| 446 | ♀ | March 26, 1878 | 0.40 | 0.77 | 1.00 | 2.45 | 1.90 | 0.36 | 0.57 | 0.14 |
| | | From the above is obtained— | | | | | | | | |
| | | Mean of six specimens | 0.40 | 0.73 | 0.97 | 2.56 | 1.80 | 0.35 | 0.54 | 0.13 |
| | | Minimum of six specimens | 0.38 | 0.69 | 0.95 | 1.45 | 1.60 | 0.34 | 0.52 | 0.12 |
| | | Maximum of six specimens | 0.42 | 0.80 | 1.01 | 2.75 | 1.90 | 0.36 | 0.57 | 0.14 |

I shall now proceed to compare these results with six specimens of *Sorex Cooperi* taken at the same place, and most of them on the same day. These six are selected from the preceding list of *Sorex Cooperi*, and will be found to be mature specimens, and a fair comparison can therefore be properly instituted between them and the specimens of *S. pachurus*.

*Measurements of six specimens of S. Cooperi.*

| Number. | Sex. | Date of collecting. | From tip of nose to— | | | | Tail to end of vertebræ. | Length of— | | Width of palms. |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Eye. | Ear. | Occiput. | Tail. | | Fore foot. | Hind foot. | |
| 383 | ♀ | December 1, 1877.... | 0.35 | 0.70 | 0.80 | 2.25 | 1.65 | 0.25 | 0.45 | ........ |
| 896 | ♀ | December 19, 1877.... | 0.36 | 0.65 | 0.80 | 2.05 | 1.65 | 0.26 | 0.45 | ........ |
| 403 | ♀ | December 24, 1877.... | 0.34 | 0.68 | 0.78 | 2.10 | 1.55 | 0.28 | 0.44 | ........ |
| 415 | ♀ | March 4, 1878 ....... | 0.34 | 0.65 | 0.76 | 2.00 | 1.70 | 0.27 | 0.47 | 0.10 |
| 420 | ♂ | March 14, 1878 ....... | 0 35 | 0.68 | 0.85 | 2.00 | 1.55 | 0.27 | 0.47 | 0.10 |
| 447 | ♂ | March 26, 1878 ....... | 0.35 | 0.68 | 0.82 | 2.15 | 1.85 | 0.25 | 0.46 | 0.10 |
| | | From the above is obtained— | | | | | | | | |
| | | Mean of six specimens............... | 0.35 | 0.59 | 0.80 | 2.09 | 1.66 | 0.26 | 0.45 | 0.10 |
| | | Minimum of six specimens.............. | 0.34 | 0.65 | 0.76 | 2.00 | 1.55 | 0.25 | 0.44 | 0.10 |
| | | Maximum of six specimens.............. | 0.36 | 0.70 | 0.85 | 2.25 | 1.85 | 0.28 | 0.47 | 0.10 |

We thus see that in only two instances does the maximum of the measurements of these six specimens of *S. Cooperi* exceed the minimum of the measurement of *S. pachyurus*, viz, from tip of nose to ear 0.70 in *S. Cooperi* to 0.69 in *S. pachyurus*, and in length of tail, which in *S. Cooperi* is 1.85 as against 1.60 in minimum of *S. pachyurus;* and it must be borne in mind that the specimen of *S. Cooperi* showing this length of tail is an extreme case, nearly 0.20 of an inch above the average length of the six specimens taken for comparison. All the other measurements are below the minimum ones of the six specimens of *Sorex pachyurus*, and the mean of the specimens of *S. Cooperi* is considerably below that of *S. pachyurus*.

I regret that the number of specimens of *S. pachyurus* at my command is not greater, but I do not believe that the average measurements of a larger number would give results differing materially from those here obtained.

To the collector the difference between the two species is very striking. *S. Cooperi* is a lithe animal, and never presents the heavy, stumpy appearance of *S. pachyurus*. In fact, to such an extent is this the case that I experience no difficulty in distinguishing the two species on sight.

We thus find on comparing specimens secured at the same time of year, in the same locality, and carefully measured in the flesh by the same person, all under precisely similar conditions, and then showing such great differences, that we cannot but be dealing with *two* different species of the genus *Sorex*.

## RODENTIA.

### FAMILY ZAPODIDÆ.

### GENUS ZAPUS, Coues.

ZAPUS HUDSONIUS (Zimm.), C. & G.—*Jumping Mouse.*

The jumping mouse is, perhaps, as common in the vicinity of Fort Custer as at most places, as, so far as is now known, it is nowhere particularly numerous.

**Measurements of specimens taken are as follows:**

| Number. | Sex. | Date of collecting. | From tip of nose to— Eye. | Ear. | Occiput. | Tail. | Tail to end of vertebræ. | Length of— Fore foot. | Hind foot. | Width of palms. | Height of ears. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 196 | ♂ | July 21, 1877 | 0.42 | 0.84 | 1.00 | 3.10 | 5.00 | 0.41 | 1.06 | 0.14 | 0.46 |
| 202 | ♂ | August 22, 1877 | 0.43 | 0.67 | 0.96 | 3.50 | 4.70 | 0.41 | 1.07 | 0.14 | 0.46 |
| 206 | ♂ | September 7, 1877 | 0.38 | 0.80 | 1.07 | 3.10 | 5.50 | 0.41 | 1.11 | 0.15 | 0.38 |
| 207 | ♂49 | September 7, 1877 | 0.37 | 0.75 | 0.90 | 2.90 | 4.70 | 0.38 | 1.04 | 0.12 | 0.36 |
| 210 | ♀ | September 10, 1877 | 0.40 | 0.77 | 1.02 | 3.10 | 5.10 | 0.39 | 1.12 | 0.14 | 0.43 |
| 211 | ♀ | September 10, 1877 | 0.42 | 0.74 | 1.03 | 3.20 | 5.00 | 0.39 | 1.08 | 0.14 | 0.47 |
| 212 | ♂ | September 11, 1877 | 0.40 | 0.74 | 1.02 | 3.10 | 5.00 | 0.41 | 1.16 | 0.15 | 0.44 |
| 213 | ♂ | September 11, 1877 | 0.41 | 0.78 | 1.00 | 3.00 | 4.80 | 0.41 | 1.06 | 0.14 | 0.40 |
| 214 | ♂ | September 11, 1877 | 0.41 | 0.80 | 1.04 | 3.00 | 5.10 | 0.41 | 1.16 | 0.15 | 0.43 |
| 221 | ♂ | September 19, 1877 | 0.35 | 0.73 | 0.97 | 3.10 | 5.00 | 0.42 | 1.07 | 0.15 | 0.46 |
| 222 | ♂ | September 19, 1877 | 0.40 | 0.73 | 0.97 | 3.10 | 5.00 | 0.39 | 1.10 | ...... | 0.37 |
| 223 | ♂ | September 21, 1877 | 0.40 | 0.75 | 1.03 | 3.00 | 5.30 | 0.45 | 1.15 | 0.14 | 0.39 |
| 224 | ♂ | September 21, 1877 | 0.40 | 0.72 | 0.98 | 3.10 | 5.25 | 0.40 | 1.13 | 0.14 | 0.38 |
| 225 | ♂ | September 21, 1877 | 0.41 | 0.76 | 0.93 | 2.90 | 5.00 | 0.45 | 1.12 | 0.14 | 0.40 |
| 234 | ♂ | September 24, 1877 | 0.35 | 0.72 | 0.98 | 3.10 | 5.00 | 0.41 | 1.13 | 0.15 | 0.40 |
| 236 | ♂ | September 24, 1877 | 0.38 | 0.76 | 1.03 | 3.00 | 5.10 | 0.41 | 1.10 | 0.16 | 0.40 |

## FAMILY MURIDÆ.

### SUBFAMILY MURINÆ.

### GENUS MUS, Linn.

MUS MUSCULUS, Linn.—*Common House Mouse.*

Thus early has the common house mouse succeeded in making its way to the Big Horn region. I took several specimens at Fort Custer in August, 1878.

### GENUS NEOTOMA, Say & Ord.

NEOTOMA CINEREA (Ord.), Baird.—*Rocky Mountain Rat.*

Common along the Yellowstone River above Fort Keogh. At Terry's Landing on the Yellowstone, just above the mouth of the Big Horn, it was very abundant, and at Fort Custer I heard complaints of the damage done to the gardens by this rat and of its being partial to watermelons.

The mountain rat is a great thief, carrying off almost everything it can lay hold of, without regard to the article being of any use to them; thus I have heard hunters and others speak of its conveying their candles, ammunition, socks, boots, and other articles of clothing to a cache, and in the majority of instances this is the last the person knows of his property.

### GENUS HESPEROMYS.

### SUBGENUS VESPERIMUS, Coues.

HESPEROMYS (VESPERIMUS) LEUCOPUS, Raf.—*White-footed Mouse.*

True *H. leucopus* was first met with at Terry's Landing August 13, and is there very abundant, as also the shorter-tailed variety known as *Sonoriensis*.

At Fort Custer I found both to be common; in fact, they are the characteristic mice of the general region of the Yellowstone and Big Horn.

Measurements of specimens taken are as follows:

| Number. | Sex. | Date of collecting. | From tip of nose to— | | | | Tail to end of vertebræ. | Length of— | | Width of palms. | Height of ears. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Eye. | Ear. | Occiput. | Tail | | Fore foot. | Hind foot. | | |
| 110 | ♂ | March 26, 1877 | 0.46 | 0.93 | 1.11 | 3.60 | 2.60 | 0.41 | 0.69 | ...... | 0.53 |
| 372 | ♂ | November 13, 1877 | 0.55 | 0.85 | 1.24 | 3.40 | 3.00 | 0.45 | 0.81 | 0.17 | 0.48 |
| 375 | ♂ | November 14, 1877 | 0.52 | 0.91 | 1.19 | 3.50 | 3.25 | 0.44 | 0.82 | 0.18 | 0.62 |
| 376 | ♂ | November 14, 1877 | 0.46 | 0.82 | 1.10 | 3.00 | 2.50 | 0.38 | 0.70 | 0.15 | 0.55 |
| 441 | ♂ | March 26, 1878 | 0.49 | 0.85 | 1.23 | 3.20 | 2.50 | 0.40 | 0.71 | 0.16 | 0.53 |
| 455 | ♀ | March 27, 1878 | 0.48 | 0.90 | 1.13 | 3.40 | 2.95 | 0.40 | 0.75 | 0.16 | 0.57 |
| 486 | ♂ | June 17, 1878 | 0.50 | 0.90 | 1.20 | 3.50 | 2.75 | 0.45 | 0.75 | 0.15 | 0.56 |
| 487 | ♂ | June 21, 1878 | 0.50 | 0.83 | 1.09 | 2.80 | 2.35 | 0.40 | 0.68 | 0.13 | 0.53 |
| 492 | ♂ | June 30, 1878 | 0.45 | 0.78 | 1.04 | 3.00 | 2.25 | 0.37 | 0.70 | 0.15 | 0.54 |
| 495 | ♂ | July 1, 1878 | 0.48 | 0.85 | 1.07 | 3.00 | 2.20 | 0.44 | 0.70 | 0.14 | 0.54 |
| 496 | ♂ | July 1, 1878 | 0.48 | 0.82 | 1.07 | 2.90 | 2.50 | 0.40 | 0.70 | 0.14 | 0.55 |
| 498 | ♂ | July 3, 1878 | 0.48 | 0.91 | 1.10 | 3.05 | 2.40 | 0.34 | 0.72 | 0.13 | 0.55 |
| 859 | ♂ | August 18, 1878 | 0.54 | 1.00 | 1.12 | 3.20 | 2.90 | 0.44 | 0.78 | 0.18 | 0.60 |
| 860 | ♂ | August 18, 1878 | 0.47 | 0.80 | 1.04 | 2.80 | 2.40 | 0.40 | 0.71 | 0.15 | 0.66 |
| 861 | ♂ | August 18, 1878 | 0.53 | 0.96 | 1.15 | 3.20 | 2.75 | 0.43 | 0.76 | 0.16 | 0.64 |
| 862 | ♂ | August 18, 1878 | 0.45 | 0.78 | 1.01 | 2.75 | 2.50 | 0.42 | 0.76 | 0.15 | 0.56 |
| 885 | ♂ | August 30, 1878 | 0.60 | 0.97 | 1.25 | 3.50 | 3.00 | 0.40 | 0.78 | 0.17 | 0.68 |

I have not yet completed my studies of the white-footed mouse, and I therefore reserve for a future occasion much that I have to say regarding it.

### SUBGENUS ONYCHOMYS, Baird.

HESPEROMYS (ONYCHOMYS) LEUCOGASTER (Maxim.), Baird.—*Missouri Mouse.*

A specimen was secured September 1, 1878, at Fort Custer, Mont. On the morning of the date above mentioned Colonel Brackett called my attention to the very strange scene of an encounter between this mouse and a young hen. The endeavors of the mouse to escape the pecks of the hen were finally successful, and it succeeded in making its way under a board, from which place it was taken in a dying condition.

This occurrence of the Missouri mouse at Fort Custer extends our knowledge of the geographical range of this species very materially, as it is now known to range from Fort Sisseton, on the Coteau des Prairies of Dakota Territory,* westward beyond the Yellowstone River.

The specimen taken at Fort Custer measured as follows:

No. 887 ♂, collected by Dr. C. E. McChesney.

| | |
|---|---|
| From tip of nose to eye | 0.58 |
| From tip of nose to ear | 1.11 |
| From tip of nose to occiput | 1.47 |
| From tip of nose to tail | 3.80 |
| Tail to end of vertebræ | 1.90 |
| Length of fore foot | 0.46 |
| Length of hind foot | 0.84 |
| Height of ears | 0.55 |
| Width of palms | 0.17 |
| Longest whiskers | 1.34 |

Fort Custer, Mont., September 1, 1878.

I include the measurement of additional specimens of this little-known mammal taken at Fort Sisseton, Dakota, since the issue of my notes referred to and now published for the first time.

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* See my notes on the mammals of Fort Sisseton, Dakota, in Bulletin United States Geological and Geographical Survey of the Territories, Vol. iv, No. 1, pp. 205, 206, and 207.

| Number. | Sex. | Date of collecting. | From tip of nose to— |  |  |  | Tail to end of vertebræ. | Length of— |  |  | Width of palms. | Height of ears. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  | Eye. | Ear. | Occiput. | Tail. |  | Fore foot. | Hind foot. | Longest whiskers. |  |  |
| 233 | ♂ | September 24, 1877...... | 0.54 | 1.07 | 1.35 | 4.30 | 1.60 | 0.50 | 0.84 | ...... | 0.18 | 0.45 |
| 480 | ♂ | May 17, 1878............ | 0.52 | 0.94 | 1.21 | 3.60 | 1.85 | 0.55 | 0.84 | ...... | 0.19 | 0.60 |
| 488 | ♀ | June 21, 1878............ | 0.60 | 1.07 | 1.44 | 4.00 | 1.80 | 0.60 | 0.86 | 1.40 | 0.22 | 0.60 |
| 489 | ♀ | June 22, 1878............ | 0.57 | 1.03 | 1.37 | 4.10 | 1.80 | 0.54 | 0.86 | 1.21 | 0.22 | 0.62 |
| 490 | ♂ | June 25, 1878............ | 0.53 | 1.02 | 1.38 | 4.00 | 1.80 | 0.53 | 0.87 | 1.18 | 0.23 | 0.59 |
| 491 | ♀ | June 30, 1878............ | 0.53 | 1.00 | 1.31 | 3.75 | 1.50 | 0.53 | 0.87 | 1.23 | 0.20 | 0.64 |
| 499 | ♂ | July 4, 1878............ | 0.58 | 1.11 | 1.39 | 4.00 | 1.75 | 0.47 | 0.86 | 1.18 | 0.21 | 0.62 |
| 500 | ♀ 49. | July 6, 1878............ | 0.51 | 0.91 | 1.28 | 3.50 | 1.65 | 0.47 | 0.86 | 1.25 | 0.20 | 0.60 |
|  |  | From the above is obtained— |  |  |  |  |  |  |  |  |  |  |
|  |  | Mean* of seven specimens............ | 0.55 | 1.03 | 1.35 | 3.95† | 1.73 | 0.53 | 0.86 | 1.24 | 0.21 | 0.59 |
|  |  | Mean of twelve specimens before taken at Fort Sisseton......... | 0.56 | 1.03 | 1.33 | 4.25 | 1.73 | 0.52 | 0.85 | ...... | 0.21 | 0.52 |
|  |  | Minimum of nineteen specimens............ | 0.45 | 0.90 | 1.20 | 3.60 | 1.17 | 0.41 | 0.78 | 1.18 | 0.18 | 0.44 |
|  |  | Maximum of nineteen specimens............ | 0.63 | 1.20 | 1.44 | 4.90 | 2.00 | 0.63 | 0.90 | 1.40 | 0.23 | 0.67 |

* No. 500 excluded on account of age.

† This mean differs 0.30 of an inch from that of the 12 specimens, which is probably to be accounted for by the immaturity of specimens Nos. 480 and 491, which it would be better to exclude.

## SUBFAMILY ARVICOLINÆ.

### GENUS ARVICOLA, Lacépède.

### SUBGENUS PEDOMYS, Baird.

**ARVICOLA (PEDOMYS) AUSTERUS CURTATUS, Cope, Baird.**—*Prairie Meadow Mouse.*

A specimen of var. *curtatus*, captured in the grain-house at Fort Custer, spring of 1878, was forwarded by Colonel Brackett to the Smithsonian Institution, where it was identified by Professor Baird.

I did not succeed in taking any specimens of this mouse, and I do not think it is at all common in the Big Horn region.

### GENUS FIBER, Cuvier.

**FIBER ZIBETHICUS (Linn.), Cuvier.**—*Muskrat.*

Occurs in small numbers on the Little Horn River above Fort Custer Mountain, and is, perhaps, to be found in other of the mountain streams of the Big Horn region, but on account of the presence of the mink, and perhaps of other enemies, it is not common in this section.

## FAMILY GEOMYIDÆ.

### GENUS THOMOMYS, Maxim.

**THOMOMYS TALPOIDES (Rich.), Baird.**—*Fort Union Gopher.*

Saw the mounds of pouched gophers, which probably belonged to this species, crossing from Custer to Fort Ellis Mountain. No specimens were taken.

## FAMILY SCIURIDÆ.

**SCIURUS HUDSONIUS, Pallas.**—*Red Squirrel.*

Occurs in numbers in the Big Horn region wherever there is pine timber.

**TAMIAS STRIATUS, Linn.**—*Chipmunk.*

Is common in the bluffs and around the pine trees near Fort Custer Mountain. Var. *quadrivittatus* I believe to be represented in the region of the Big Horn.

**SPERMOPHILUS TRIDECEM LINEATUS** (Mich.), Aud. and Bach.—*Striped Prairie Squirrel.*

Is common at the mouth of the Yellowstone River, and along that stream as far as Fort Keogh, after leaving which point it appeared to rapidly diminish in numbers, and I saw none around Fort Custer, or on the trip to Fort Ellis, although it doubtless occurs through that section, though perhaps in small numbers.

### GENUS CYNOMYS, Raf.

**CYNOMYS LUDOVICIANUS**, Baird.—*Prairie Dog.*

Saw quite a number August 14, 1878, on the high land above Terry's Landing on the Yellowstone River, and also along the road, at intervals, to Fort Custer, where the animals are to be seen on every pleasant day frolicking about the parade-ground.

Colonel Brackett informed me that they were out of their holes on every fine day during the winter of 1877–'78 at Fort Custer, and that in the spring, when the severe snow and rain storm of March flooded the parade ground, the dogs became very tame and went into the men's quarters for shelter, even eating in the barracks almost out of the men's hands.

I have seen many attempts made to domesticate the prairie dog, but none that were thoroughly successful, as they seemed ever ready to bite on the slightest provocation and to return to their wild state.

### GENUS ARCTOMYS, Schrober.

**ARCTOMYS FLAVIVENTER**, Aud. and Bach.—*Yellow-bellied Marmot.*

Are common in the vicinity of Fort Custer, where their holes may be seen in large numbers on the hills south of the Little Horn River. Also found in numbers in the Big Horn Mountains.

## FAMILY CASTORIDÆ.

### GENUS CASTOR, Linn.

**CASTOR CANADENSIS**, Kuhl.—*American Beaver.*

Evidences of the presence of the beaver were numerous all along the Missouri River from Bismarck to Fort Buford, and also along the Yellowstone River from the latter place to Terry's Landing, from July 25 to August 14. I saw trees from 12 to 18 inches through that had been entirely cut off by the beavers. Is common on the Big and Little Horn Rivers.

I was informed at Fort Custer that many beaver skins had been brought into that post for trade in the spring of 1878, and were taken by trappers in the vicinity of the post, along the Big and Little Horn Rivers. Several young were brought to Fort Custer for trade by the Crow Indians May 29, 1878.

## FAMILY HYSTRICIDÆ.

### GENUS ERETHIZON, F. Cuvier.

**ERETHIZON EPIXANTHUS**, Brandt.—*Yellow-haired Porcupine.*

A large and fine animal of this species was seen by Captain Spaulding, Second Cavalry, near the banks of the Little Horn River, about two miles from Fort Custer, August 1, 1878, and another was seen the latter part of May in the Bad-lands, about 20 miles from Fort Custer, near the mouth of Rotten Grass Creek.

## FAMILY LEPORIDÆ.

### GENUS LEPUS, Linn.

**LEPUS CAMPESTRIS**, Bach.—*Northern Prairie Hare.*

Occurs in small numbers throughout the Big Horn region; several were shot at Fort Custer in the spring of 1878.

**LEPUS SYLVATICUS**, Bach.—*Gray Rabbit.*

Is common all along the Big Horn River, from Terry's Landing to Fort Custer and above that post.

I also found it abundant among the pines in a spur of the Big Horn Mountains August 27 and 28, 1878. I believe this rabbit to be abundant throughout Montana and adjacent country.

In the vicinity of Fort Custer I found that this rabbit lived in burrows almost exclusively, coming out during the day-time for their airing, and when disturbed away from their holes, concealing themselves under a convenient lumber pile, from which they were frequently taken alive by some enterprising cook, just in the nick of time to be served at the coming meal.

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## CHAPTER II.

# Birds.

### ORDER PASSERES.

### FAMILY TURDIDÆ.

**TURDUS MIGRATORIUS**, Linn.—*Robin.*

Colonel Brackett informs me that the robin is quite abundant at Fort Custer in the spring-time, and that it breeds in that vicinity. I met with none in the immediate vicinity of that post, but saw several about the middle of September, while on the road to Fort Ellis, Montana.

**TURDUS NÆVIUS**, Gm.—*Varied Thrush.*

August 20, 1878, I found this thrush in numbers in the timber along the Big and Little Horn Rivers, near Fort Custer.

Specimen No. 866 ♂ furnish the following measurements: 16.00×10.00; wing, 5.00; tail, 3.70; tars., 1.32; middle toe and claw, 1.11; bill, 1.67.

**TURDUS SWAINSONI**, Cab.—*Olive-back Thrush.*

Seen in a spur of the Big Horn Mountains August 30 in some numbers. I believe the olive-back thrush breeds in this region.

**OROSCOPTES MONTANUS**, Towns.—*Mountain Mocking-bird.*

I did not find the mountain mocking-bird at all as common as I expected in this region. I saw a few in a spur of the Big Horn Mountains August 28, 29, and 30, as also in crossing to Fort Ellis in September, but they did not seem to be present in any numbers; but I doubt not it is far more abundant earlier in the season.

**MIMUS CAROLINENSIS** (Linn.), Gr.—*Catbird.*

A few were seen along the Yellowstone, below Fort Keogh, Montana, but above that post I did not meet with this bird, and I do not believe it ascends that river to any great distance. It was very common along the Missouri at and above Bismarck, and it probably advances with or slightly ahead of civilization, although I have met with it it in small numbers far inland in suitable localities; still, for the most part, the catbird prefers to be near man's habitations.

**HARPORHYNCHUS RUFUS** (Linn.), Cab.—*Brown Thrush.*

Three thrashers were seen August 27 and 28 in a spur of the Big Horn Mountains; but, as elsewhere in my experience with this bird, I found them very shy.

Specimen No. 671 ♂ furnishes the following measurements: 13.25×11.50; wing, 4.22; tail, 5.30; bill, 1.13; middle toe and claw, 1.13.

### FAMILY SAXICOLIDÆ.

**SIALIA ARCTICA**, Sw.—*Arctic Bluebird.*

In the pine region I found this bluebird to be very common. Observed in a spur of the Big Horn Mountains August 27, 28, and 29, and also crossing to Fort Ellis, Montana, in September. Doubtless breeds in the pines of the Bighorn region in large numbers.

Specimens collected furnish the following measurements:

No. 877 ♂, 12.50×6.60; wing, 4.25; tail, 2.57; tars., 0.93; middle toe and claw, 0.82; bill, 0.52.

No. 878 ♀, 13.00×6.90; wing, 4.50; tail, 2.65; tars., 0.94; middle toe and claw, 0.82; bill, 0.53.

### FAMILY CINCLIDÆ.

CINCLUS MEXICANUS, Sw.—*Water Ouzel.*

From the accounts of hunters and trappers the water ouzel is found in the streams in the Big Horn Mountains. A bird behaving very strangely, they tell me, is occasionally seen in that region, which, from their description of its actions, can be no other than *C. mexicanus.*

### FAMILY PARIDÆ.

PARUS ATRICAPILLUS, L. VAR SEPTENTRIONALIS, Harris.—*Long-tailed Chickadee.*

August 20 at Fort Custer I secured several specimens of the long-tailed chickadee in the woods along the Little Horn River; observed them in the pine region in large numbers; in fact they were the characteristic bird of the pines at the time of my visit the latter part of August. I doubt not they breed in this region.

The specimens secured measure as follows:

No 868 ♀, 8.50×5.60. Wing, 2.80; tail, 3.00; tars., 0.72; middle toe and claw, 0.54; bill, 0.39.

No. 876 ♂, 8.65×5.50. Wing, 2.70; tail, 2.75; tars., 0.73; middle toe and claw, 0.53.

PARUS MONTANUS, Gamb.—*Mountain Chickadee.*

I did not meet with the mountain chickadee anywhere, but it is known to inhabit the general region under consideration. All the specimens of chickadees taken seemed to be referable to the preceding variety.

### FAMILY SITTIDÆ.

SITTA CAROLINENSIS, Gm.—*Carolina Nuthatch.*

In a spur of the Big Horn Mountains August 29 I secured a single specimen of true *S. Carolinensis*, as per measurement of bill. This was the only bird of the species seen.

No. 880 ♂, 10.00×5.30. Wing, 3.45; tail, 1.90; tars., 0.67; middle toe and claw, 0.74; bill, 0.69; at base, 0.17.

### FAMILY TROGLODYTIDÆ.

SALPINCTES OBSOLETUS, Say.—*Rock Wren.*

The rock wren was observed in small numbers while crossing from Custer to Fort Ellis in September.

TROGLODYTES AËDON V. var. PARKMANNI, (Aud.) Coues.—*Western House Wren.*

August 20, saw several western house wrens in the woods along the Little Horn River, near Fort Custer, Montana.

### FAMILY ALAUDIDÆ.

EREMOPHILA ALPESTRIS (Forst.), Boie.—*Horned Lark.*

Colonel Brackett informs me that this bird was abundant at Fort Custer during the winter of 1879 and 1878, and in the spring of 1878. I observed it every day during the entire period of my stay at Custer in August and September and consequently I infer that the bird is resident in the Big Horn region.

Measurements of specimen No. 601 ♂: 13.00×7.50; wing, 4.12; tail, 3.00.

### FAMILY MOTACILLIDÆ.

NEOCORYS SPRAGUEI, Sclat.—*Missouri Skylark.*

I observed but one bird of this species on the entire journey, and that one was seen when crossing from Custer to Fort Ellis, in September.

### FAMILY SYLVICOLIDÆ.

DENDROECA ÆSTIVA (Gm.), Bd.—*Summer Yellowbird.*

The summer yellowbird was everywhere abundant. From Bismarck up the Missouri and Yellowstone Rivers and throughout the Big Horn region it was the most common of all the birds met with.

Specimen No. 869 ♀ measures as follows: 8.00×5.10; wing, 2.40; tail, 1.85; tars., 0.80; middle toe and claw, 0.55; bill, 0.37.

**DENDRŒCA AUDUBONI**, Towns.—*Audubon's Warbler.*

Among the pines in a spur of the Big Horn Mountains, August 27, 28, and 29, I found this warbler in numbers. It was not observed elsewhere on the expedition.

No. 875 ♂, 8.60×5.50; wing, 3.00; tail, 2.35; tars., 0.83; middle toe and claw, 0.68;

Specimens secured furnish the following measurements:

bill, 0.45.

No. 879 ♀, 8.70×5.60; wing, 3.00; tail, 2.35; tars., 0.85; middle toe and claw, 0.69; bill, 0.47.

**ICTERIA VIRENS** (Linn.), Bd.—*Yellow breasted Chat.*

Was observed several times in September on the journey from Fort Custer to Fort Ellis, Mont.

### FAMILY HIRUNDINIDÆ.

**HIRUNDO HORREORUM**, Barton.—*Barn Swallow.*

Is not common. A few specimens were secured along the Little Horn River, near Fort Custer. I also observed it occasionally along the Yellowstone River.

Specimens measure as follows:

No. 643 ♂, 12.70×5.70; wing, 4.55; tail, 3.80; tarsus, 0.45; middle toe and claw, 0.57; bill, 0.25.

No. 867 ♂, 13.00×6.10; wing, 4.90; tail, 3.35; tarsus, 0.50; middle toe and claw, 0.60; bill, 0.30.

**PETROCHELIDON LUNIFRONS** (Say), Cab.—*Cliff Swallow.*

Was very common along the Yellowstone River, between Fort Keogh and Terry's Landing. The nests of these birds were seen in great numbers on the cliffs overhanging the river banks. Often a favorable place would be thickly covered, and I have seen where their nests extended nearly half a mile with scarcely a bare spot.

Specimens secured measure as follows:

No. 645, ♂ 12.50×5.70; wing, 4.18; tail, 1.94.

No. 646, ♀ 12.50×6.20; wing, 4.05; tail, 2.10.

**COTYLE RIPARIA**, Linn.—*Bank Swallow.*

Occurs in considerable numbers throughout the Big Horn region.

**PROGNE PURPUREA** (Linn.), Boie.—*Purple Martin.*

Is not common in this region. A single pair only were seen along the Yellowstone River August 9.

### FAMILY AMPELIDÆ.

**AMPELIS CEDRORUM**, (V.), Bd.—*Cedar Bird.*

Was observed along the Yellowstone River above Fort Custer in September, as also among the pines, though not in any numbers.

### FAMILY VIREONIDÆ.

**VIREO SOLITARIUS**, Wils.—*Solitary Vireo.*

Seen August 30 in small numbers among the pines in a spur of the Big Horn Mountains. One specimen only was secured representing the pale variety.

No. 886 ♂, 9.95×5.70; wing, 3.25; tail, 2.28; tarsus, 0.80; middle toe and claw, 0.63; bill, 0.41; spur quill, 0.60.

### FAMILY LANIIDÆ.

**COLLURIO LUDOVICIANUS**, L. var. **EXCUBITORIDES**, Sw.—*White-rumped Shrike.*

Was observed in the mountains in some numbers.

### FAMILY FRINGILLIDÆ.

**LEUCOSTICTE TEPHROCOTIS**, Sw.—*Gray-crowned Finch.*

In a letter recently received from Col. A. G. Brackett, United States Army, dated Fort Custer, January 26, 1879, he says: "In November last I saw some gray-crowned finches at Fort Keogh, and on the 2d of January saw quite a large flock here."

I can readily understand the appearance of this bird at Fort Custer in January, as such is in accord with the testimony of the majority of observers, but its occurrence at Fort Keogh in November is an interesting observation, as the altitude of that post is much less than that of Fort Custer, and the natural route of the bird to Fort Keogh should be by way of Fort Custer, but careful search may yet show it to be nearly resident in the Big Horn Mountains.—C. E. McC., Fort Sisseton, D. T., March 1, 1879.

Chrysomitris tristis (Linn.), Bp.—*Thistle Bird.*

Observed along the Yellowstone River, August 13, 1878. Colonel Brackett informs me it is quite common along this river during the summer months. On August 24 I saw a great many at Fort Custer, and all the adults were in the September plumage, but the birds of the year had not yet undergone this change.

Chrysomitris pinus, Wils.—*Pine Finch.*

Was seen in small numbers, crossing from Fort Custer to Fort Ellis, in September.

Plectrophanes nivalis, Meyer.—*Snow Bunting.*

Through the kindness of Colonel Brackett, I am able to add the snow bunting to the list of birds of the Big Horn region. In a letter dated Fort Custer, Mont., April 11, 1879, he informs me that snow buntings were observed there during the latter part of the winter, the first he had seen in that region.—C. E. McC., Fort Sisseton, May 13, 1879.

Plectrophanes ornatus, Towns.—*Chestnut-collared Longspur.*

I saw a number of quite large flocks, from 40 to 100 birds in each, early in September. They had evidently just arrived from the north.

Specimen No. 615, ♂ 10.75×6 00.
Specimen No. 616, ♂ 10.50×6.00.

Pooecetes gramineus, Gm. var. confinis, Bd.—*Western Grass Finch.*

Throughout the whole of the Big Horn region this finch is very common. Breeds over its entire range.

Spizella monticola (Gm.), Bd.—*Tree Sparrow.*

I did not find the tree sparrow at all common. A few were seen on the road from Terry's Landing to Fort Custer, but I did not meet with it either on the Yellowstone or the Big Horn Rivers.

Secimen No. 605 furnishes the following measurements: 9.37×6.38; wing, 3.00; tail, 3.00.

Spizella socialis (Wils.), Bp. var. Arizonæ, Coues.—*Arizona Chipping Sparrow.*

I did not meet with this bird along the wooded streams, but in a spur of the Big Horn Mountains, August 29, I saw quite a number. One specimen only was secured, the measurements of which are as follows:

No. 884 ♂, 8.50+5.20; wing, 2.70; tail, 2.50; tarsus, 68; middle toe and claw, 62; bill, 0.35; at base, 0.20.

Spizella pallida (Sw.), Bp.—*Clay-colored Sparrow.*

Was quite common in the bottom north of Custer, where I observed it in August and September.

Chondestes grammaca, Say.—*Lark Finch.*

Is quite common among the pines in the mountains, where I saw a great many, August 29.

Specimen No. 883 ♂, measures as follows: 10.50 × 6.30; wing, 3.30; tail, 2.68; tarsus, 0.79; middle toe and claw, 0.77; bill, 0.47; at base, 0.30.

Calamispoza bicolor (Towns.), Bp.—*White-winged Blackbird.*

Occurs throughout the region of the Big Horn in numbers during August; migratory.

Pipile maculatus var artica, Sw.—*Arctic Towhee.*

I saw but a very few arctic towhees at Fort Custer. August 24 I secured a specimen, and another was taken on the 30th in a spur of the Big Horn Mountains.

No. 874 ♂, measures as follows: 10.55 × 8.00; wing, 3.30; tail, 3.60; tarsus, 1.13; middle toe and claw, 1.06; bill, 0.52.

## FAMILY ICTERIDÆ.

**DOLICHONYX ORYZIVORUS** (Linn.), Sw.—*Rice Bird.*

The rice bird I did not find to be at all common in the Big Horn region. A few were seen on the Yellowstone, August 13.

It is possible that this bird had bred and taken its departure before my arrival at Fort Custer.

Specimens taken measure as follows:

| Number. | Sex. | By whom collected. | Extent. | Length. | Wing. | Tail. | Tarsus. | Middle toe and claw. | Bill. |
|---|---|---|---|---|---|---|---|---|---|
| 638 | ♂ | Dr. C. E. McChesney | 12.00 | 6.90 | 3.67 | 2.83 | 1.05 | 1.09 | 0.57 |
| 639 | ♂ | Dr. C. E. McChesney | 12.25 | 7.00 | 3.84 | 2.75 | 0.98 | 1.13 | 0.53 |
| 648 | ♂ | Dr. C. E. McChesney | 12.50 | 7.25 | ...... | ...... | ...... | ........ | ...... |

**MOLOTHRUS ATER** (Gm.), Sw.—*Cowbird.*

Was very common along the Yellowstone River and at Fort Custer, Mont.

No. 614 ♀, measures in extent 13.50; length, 8.50.

**AGELÆUS PHŒNICEUS** (L.), Vieill.—*Red-winged Blackbird.*

Was not seen above Bismarck on the Missouri, and I do not believe this blackbird enters the Big Horn region.

**STURNELLA MAGNA** (L.), Sw. var. **NEGLECTA** (Aud.), Allen.—*Western Fieldlark.*

The western fieldlark I found everywhere very common, especially so along the Yellowstone River above Fort Custer, where it had already, September 10th, congregated in flocks, and were probably about to depart.

Specimens taken measure as follows:

No. 608×16.50×9.50.

No. 609×16.75×10.00.

No. 610×15.75×9.75.

**ICTERUS BULLOCKII**, Bp.—*Bullock's Oriole.*

In a letter dated Fort Custer, Mont., June 7, 1879, Colonel Brackett kindly conveys to me information of the occurrence of this oriole at that post on that date, and that he also observed on that day a golden eagle.

I have no doubt but that Bullock's Oriole breeds in the Big Horn region.

This raises the number of Icteridæ to 7, and the total to 103.—C. E. McC., Fort Sisseton, June 26, 1879.

**SCOLECOPHAGUS CYANOCEPHALUS** (Wagl.), Cab.—*Blue-headed Grackle.*

Was observed at Fort Custer on September 7 in large number; was not seen elsewhere; the birds made their appearance at Custer on the morning of September 7, and must have come some distance, as I had not previously met with them in the general region. They had not taken their departure when I left the post on the 9th.

**QUISCALUS PURPUREUS**, (Bartr.) Licht.—*Purple Grackle.*

Was observed in numbers at nearly every wood-yard on the Yellowstone above Fort Keogh; was common at Fort Custer; in fact wherever there were signs of civilization the purple grackle was to be found.

Specimen No. 612 ♂ measures 16.75 in extent and 12.50 in length.

## FAMILY CORVIDÆ.

**CORVUS CORAX**, Linn.—*Raven.*

Was seen in large numbers on the Yellowstone above Fort Keogh, Mont., as also at Terry's Landing. In the vicinity of Fort Custer is common. Breeds throughout this portion of its range.

Specimen No. 665 ♂ measures as follows: 40.00×22.25; wing, 13.00; tail, 7.00; bill, 2.61; at base, 1.20.

Corvus americanus, Aud.—*Common Crow.*

The common American crow was met with September 9th in large numbers near Baker's battle-field.

Picicorvus columbianus (Wils.), Bp.—*Clark's Crow.*

I met with Clark's Crow only in the mountains, where I saw a great many August 28, 29, and 30, 1878.

Pica melanoleuca Vieill. var hudsonica, Sab.—*American Magpie.*

The first magpies observed was on August 13, crossing the high table land between Terry's Landing and Fort Custer, Mont., where they were found in numbers, common throughout the mountainous portion of the Big Horn region.

I heard the same complaints of the damage done by this bird to sore-backed animals here as elsewhere, and found it to be universally despised by the mountaineers, none of whom ever had a good word to say for it.

### * Family TYRANNIDÆ.

Tyrannus carolinensis (L.), Bd.—*Kingbird.*

Was very common along the Yellowstone River in August and at Fort Custer in September.

The kingbird appears ever ready to exhibit the pugnacious character from which it has received its name. I have many times seen it sally forth from a quiet perch and fearlessly attack the largest birds of prey, and although it would frequently alight on their backs, I do not believe that, while it may have annoyed, it did any real damage, as it soon leaves its seat, and the larger bird does not appear to pay any particular attention to the circumstance from beginning to end.

Specimens secured furnished the following measurements:

No. 633 ♀ 14.85×8.45; wing, 4.63; tail, 3.35; tarsus, 0.72; bill, 0.70.

No. 644 ♂ 14.90×8.50; wing, 4.43; tail, 3.54.

Tyrannus verticalis, Say.—*Arkansas Flycatcher.*

Was observed everywhere along the Yellowstone and Big Horn Rivers, but did not appear to be as common as the preceding species.

I have never seen this bird exhibit any of the pugnacious character of its near relative, *T. carolinensis*, and I had been led to believe it was a well-behaved bird; but Mr. Henshaw, on page 342 of his report upon the zoology of the geological and geographical survey west of the 100th meridian, in charge of Lieutenant Wheeler, United States Engineer Corps (chap. 3, vol. 5, Washington, Government Printing Office, 1875), states that it possesses all the force of action and pugnacity of the kingbird.

Specimen No. 659 ♂ measured as follows: 15.75 × 8.90; wing, 5.20; tail, 3.92; tarsus, 0.75; middle toe and claw, 0.77; bill, 0.64.

Sayornis sayus, Bp.—*Say's Flycatcher.*

Occurs along the Yellowstone in small numbers. A few observed at Fort Custer, but it appeared to be in larger numbers in a spur of the Big Horn Mountains than elsewhere, although of the four species of flycatchers this one is the rarest in the Big-Horn region.

No. 881 ♂ measures as follows: 12.50 × 7.20; wing, 4; tail, 2.20; tarsus, 0.79; middle toe and claw, 0.65; bill, 0.55.

Contopus virens (L.), var. Richardsonii (Sw.), Coues.—*Western Wood Pewee.*

Was quite common along the Yellowstone and Big and Little Horn Rivers, as also among the pines in the mountains.

*Measurements of specimens.*—No. 870 ♂, 10.70 × 6.50; wing, 3.40; tail, 2.41; tarsus, 0.58; middle toe and claw, 0.47; bill, 0.51. No. 871 ♀, 10.10 × 6.10; wing, 3.10; tail, 2.29; tarsus, 0.57; middle toe and claw, 0.46; bill, 0.50.

## Order Picariæ.

### Family CAPRIMULGIDÆ.

Antrostomus nuttalli, Aud.—*Nuttall's Whippoorwill.*

A pair were heard on the evenings of August 28 and 29, while in camp on a spur of the Big Horn Mountains. They would come and sit on some tall pine within a quarter of a mile of our camp, but on opposite sides of it, and utter their sharp, wild cry, generally dropping the first syllable of their name, but occasionally it would be taken up. It was so dark both evenings that no endeavor was made to capture them, which I expect would have been attended with considerable difficulty, as they were very shy, and would fly a little further away from camp when any noise was made and continue uttering their peculiar cry, which, becoming fainter and fainter, was finally lost in distance.

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* See end of report.

**CHORDEILES VIRGINIANUS var. HENRYI, Coues.**—*Western Nighthawk.*

Is common almost everywhere in the Big Horn region. Breeds throughout its range. I have often seen this bird on cloudy days on the wing in search of its food; but on the bright and warm days of summer I have only met with it in the woods, where it selects some secluded spot where the surroundings are as favorable in regard to color, &c., as possible, and from which sometimes start up almost within a person's reach.

Specimen No. 647 ♂ measures as follows: 22.75 × 9.30; wing, 7.75; tail, 4.37; tarsus, 0.55; middle toe and claw, 0.70.

## FAMILY TROCHILIDÆ.

**SELASPHORUS RUFUS (Gm.), Sw.**—*Rufous-backed Humming-bird.*

Some of the gentlemen who were serving at Fort Custer during the summer of 1878 will recall with a smile our several attempts to capture humming-birds on the Custer bank of the Big Horn River.

The humming-birds we observed I have not yet thoroughly satisfied myself as to where they should be placed, but I put them provisionally under the head of the rufous-backed, as that is the sole boreal representative of the family, so far as is now known; and it is not improbable that future investigations will show that it occurs in the Big Horn region.

## FAMILY ALCEDINIDÆ.

**CERYLE ALCYON (L.), Boie.**—*Kingfisher.*

The belted kingfisher was quite common along the Yellowstone River from Fort Keogh to near Fort Ellis, Mont., but I did not meet with it on the smaller interior streams.

## FAMILY PICIDÆ.

**PICUS VILLOSUS, L. var HARRISI (Aud.), Allen.**—*Harris' Woodpecker.*

A single woodpecker seen at Fort Custer, Mont., August 20, is believed to belong here, although it was not secured.

**PICUS PUBESCENS, L.**—*Downy Woodpecker.*

Several were observed among the pines August 13 on the road from Terry's Landing to Fort Custer, in company with the brown-headed woodpeckers.

**SPHYRAPICUS THYROIDEUS (Cass.), Bd.**—*Brown-headed Woodpecker.*

Throughout the entire Big Horn region this woodpecker occurs in numbers. Even high up in the mountains among the pines it appeared to be as much at home as among the trees of the river bottoms.

Measurements of specimens are as follows:

| Number. | Sex. | Date of collecting. | Extent. | Length. | Wing. | Tail. | Tarsus. | Middle toe and claw. | Bill. |
|---|---|---|---|---|---|---|---|---|---|
| 863 | ♂ | August 20, 1878 | 17.50 | 10.00 | 5.70 | 3.45 | 0.95 | 1.03 | 0.91 |
| 873 | ♂ | August 24, 1878 | 17.85 | 9.95 | 5.50 | 3.50 | 0.93 | 1.03 | 0.93 |
| 882 | ♀ | August 29, 1878 | 17.50 | 9.50 | 5.80 | 3.60 | 0.85 | 1.07 | 0.94 |

**MELANERPES ERYTHROCEPHALUS (L.), Sw.**—*Red-headed Woodpecker.*

Very common along the Yellowstone and Big and Little Horn Rivers; was also seen in some numbers in the mountains.

Specimens measure as follows:
No. 655, ♀ 17.75×9.30.
No. 656, ♀ 17.25×9.50.
No. 865, ♂ 17.80×10.00; wing, 5.70; tail, 3.27; tarsus, 0.95; middle toe and claw, 1.08; bill, 1.12.

**COLAPTES AURATUS**, (L.)—*Golden-winged Woodpecker.*

Was occasionally seen while ascending the Yellowstone River, above Fort Keogh, Mont. Was very common in the woods along the Little Horn River, near Fort Custer.

The two species of *Colaptes* were found associated with the red-headed woodpecker throughout the entire region traveled.

Specimen No. 677 ♂ measures as follows: 19.00×11.75; wing, 6.25; tail, 4.50.

**COLAPTES MEXICANUS**, Sw.—*Red-shafted Woodpecker.*

Is common throughout the Big Horn region; is found in company with the preceding species.

All the species of woodpeckers treated of in this report breed in the Big Horn region.

Specimen No. 864 ♂ measures as follows; 19.30×12.25; wing, 6.50; tail, 4.30; tarsus, 1.30; middle toe and claw, 1.25; bill, 1.26.

## ORDER RAPTORES.

### FAMILY STRIGIDÆ.

**BUBO VIRGINIANUS** (Gm.), Bp.—*Great Horned Owl.*

This owl is found in suitable localities in this region; not, however, in any numbers.

**BRACHYOTUS PALUSTRIS** (Bechst.), Bp.—*Short-eared Owl.*

The only owl of this species I saw was on August 30, when returning from camp on a spur of the Big Horn Mountains with Captain Read, Eleventh Infantry. The bird was very shy, and was not secured.

**SPEOTYTO CUNICULARIA**, Mol. var. **HYPOGÆA**, Bp.—*Burrowing Owl.*

Is resident throughout the Big Horn region; wherever there is a prairie-dog village this owl will be found.

### FAMILY FALCONIDÆ.

**FALCO COLUMBARIUS**, Linn.—*Pigeon Hawk.*

Was seen several times along the Yellowstone, above Fort Keogh, Mont., and was again met with August 27 in a spur of the Big Horn Mountains in considerable numbers.

**FALCO SPARVERIUS**, Linn.—*Sparrow Hawk.*

Was abundant everywhere along the Yellowstone and Big and Little Horn Rivers, as also in the mountains.

Specimen No. 872 ♂ measures as follows: 22.75 × 10.50; wing, 7.50; tail, 5.30; tarsus, 1.32; middle toe and claw, 1.14; bill, 0.46.

**BUTEO BOREALIS** (Gm.), Vieill. var. **CALURUS** (Cass.), Ridg.—*Western Red-tailed Buzzard.*

Is quite common throughout the Big Horn region. August 19, secured a specimen at Fort Custer, Mont., showing much fulvous beneath; tail as in the young, dark-brown and fulvous barred; upper tail coverts white. Saw a living specimen of true *calurus* at Terry's Landing, taken in that vicinity.

**BUTEO SWAINSONI**, Bp.—*Swainson's Buzzard.*

Was seen in small numbers, from August 8 to 11, while ascending the Yellowstone above Fort Keogh, Mont. Was not seen around Fort Custer.

**ARCHIBUTEO LAGOPUS** (Brunn.), Gr. var. **SANCTI JOHANNIS** (Gm.), Ridg.—*Rough-legged Hawk.*

The rough-legged buzzard was observed near Little Horn River, in the neighborhood of Fort Custer, in February, 1878, by Colonel Brackett.

**ARCHIBUTEO FERRUGINEUS**, Licht.—*Ferruginous Hawk.*

The California squirrel hawk was observed several times along the Yellowstone River, above Fort Keogh, Mont. I again met with it in large numbers near Baker's battle-field, on the road to Fort Ellis, where it seemed to be congregated in the vicinity of the villages of the prairie dog, upon which it probably preyed.

**AQUILA CHRYSAËTUS**, Linn.—*Golden Eagle.*

A magnificent specimen of the golden eagle was shown me at Terry's Landing that had been captured a few miles from there by members of Captain Connell's company, Eleventh Infantry.

### FAMILY CATHARTIDÆ.

**CATHARTES AURA** (Linn.), Ill.—*Turkey Buzzard.*

Was observed by Colonel Brackett in numbers along the Yellowstone, July 14 and 31, and on August 3, 1878, he saw a large colony of them on a point on the Yellowstone, where they had evidently been breeding, as the tops of the trees were worn, and seemed almost bare of foliage on account of the number of these birds that had been roosting, resting, and flying about among them.

I observed a few along the Missouri River below Fort Buford, but did not meet with any in the vicinity of Fort Custer, Mont.

## ORDER COLUMBÆ.

### FAMILY COLUMBIDÆ.

**ZENÆDURA CAROLINENSIS** (Linn.), Bp.—*Carolina Dove.*

Was common along the Yellowstone and Big and Little Horn Rivers. At Fort Custer I would daily see hundreds in the woods; found them abundant in the mountains also.

No. 654 ♂ measures, length, 12.00; wing, 5.75; tarsus, 0.75; middle toe and claw, 1.25.

## ORDER GALLINÆ.

### FAMILY TETRAONIDÆ.

**TETRAO OBSCURUS** (Say.), Bd.—*Dusky Grouse.*

Was observed in the mountains crossing from Fort Custer to Fort Ellis in September. My experience with this bird agrees with that of Mr. G. B. Grinnell (see his zoological report as contained in Captain Ludlow's report of a reconnaissance from Carroll, Mont., to the Yellowstone National Park and return, made in the summer of 1875, being Appendix N N, annual report of the Chief of Engineers for 1876), as I observed it in September, almost always in the open creek bottoms among the mountains.

**CENTROCERCUS UROPHASIANUS** (Bp.), Sw.—*Sage Grouse.*

The sage hen is resident in the Big Horn region, as also in the Yellowstone Valley from Fort Keogh up.

The flesh of the young is good until about the 1st of October, after which it becomes too highly flavored with sage to be fit for the table.

**PEDIOECETES PHASIANELLUS** (L.), Ell. var. **COLUMBIANUS**, Bd.—*Sharp-tailed Grouse.*

Is resident and common in the region visited. Several were shot fully two-thirds grown by the 10th of August.

**BONASA UMBELLUS** (L.), Steph. var. **UMBELLOIDES**, Doug.—*Rocky Mountain Ruffled Grouse.*

Occurs in the Big Horn Mountains in considerable numbers. Is resident.

## ORDER GRALLATORES.

### FAMILY CHARADRIIDÆ.

**CHARADRIUS FULVUS**, Gm. var. **VIRGINICUS** (Bork.), Coues.—Golden Plover.

Passes the Big Horn region during the migrations, but none remain to breed within its limits.

Specimens measure as follows:
No. 684 ♂ 22.75×10.50; wing, 7.40; tail, 2.75; tarsus, 1.55; middle toe and claw, 1.23.
No. 689 ♂ 21.00×10.50; wing, 6.90; tail, 2.50.

**Aegialitis vociferus**, Linn.—*Kildeer Plover.*

The only kildeer plovers I saw on the expedition was on August 15 on the road from Terry's Landing to Fort Custer, Mont., when a single pair passed near the ambulance.

Colonel Brackett informs me that he saw several at Fort Custer in the spring of 1878.

I doubt if this bird is common or breeds in the Big Horn region. It occurs there probably only during the migrations.

Specimen No. 664 ♂ measures 19.62×10.00.

**Aegialitis asiaticus var. montanus**, Towns.—*Mountain Plover.*

Colonel Brackett informs me that the mountain plover was abundant at Fort Custer in the spring of 1878, and he thinks that they breed in that vicinity, which may be the case notwithstanding I met with none in August.

### Family RECURVIROSTRIDÆ.

**Recurvirostra americana**, Gm.—*Avocet.*

Were observed along the Yellowstone River above Fort Keogh, Mont., several times between August 8 and 13, 1878.

Specimens taken measure as follows:
No. 625 ♂ 29.00×18.85. Wing, 9.00; tail, 3.65; tarsus, 3.65; bill 3.65.
No. 628 ♂ 29.75×18.50. Wing, 9.25; tail, 4.30; tarsus, 3.65; bill, 3.90.

### Family PHALAROPODIDÆ.

**Steganopus wilsoni** (Sab.), Coues.—*Wilson's Phalarope.*

Killed on a swale above Fort Custer, Mont., 1878, and identified by Colonel Brackett. Occurs only during the migrations.

*Measurements of specimens.*—No. 634 ♀ 15.75 × 9.45; wing, 5.20; tail, 2.35; tarsus, 1.33; middle toe and claw, 1.31; bill, 1.37. No. 650 ♀ 16.25×9.65.

### FAMILY SCOLOPACIDÆ.

**Macrorhamphus griseus**, Gm.—*Red-breasted Snipe.*

Was killed near Fort Custer, Mont., on the Little Horn River, spring of 1878, and identified by Colonel Brackett. Occurs in this region only during the migrations.

**Tringa bonapartii**, Sw.—*White-rumped Sandpiper.*

A few white-rumped sandpipers were seen on the bars in the Yellowstone River above Fort Keogh August 8 to 13. Is common only during the migrations in the Big Horn region, where a few remain and breed.

Specimen No. 651 ♂ measures as follows: 15.00×7.50; wing, 4.84; tail, 1.85; tarsus, 0.93; middle toe and claw, 0.95; bill, 0.96.

**Totanus solitarius**, Wils.—*Solitary Sandpiper.*

Several times while ascending the Yellowstone River above Fort Keogh, Mont. T., the solitary sandpiper was met with on the shores of the river. Is not common.

**Actiturus bartramius**, (Wils.), Bp.—*Upland Plover.*

I did not find the upland plover near as common as I expected to in the middle of August in the Big Horn region. In fact, I met with but two birds of this species—one on the Yellowstone just below Terry's Landing, and the other on the road from that place to Fort Custer.

Specimen No. 663 ♂ measures 20.62×11.65.
Specimen No. 670 ♂ measures 20.50×12.10; wing, 4.10; tail, 2.30.

**Numenius longirostris**, Wils.—*Long-billed Curlew.*

Were seen in considerable numbers while ascending the Yellowstone above Fort Keogh in flocks, as they were also found in the vicinity of Fort Custer, Mont., August 15, 1878. They breed along the Little Horn River, and probably other streams also: the flocks seen near Fort Custer contained the birds of the year.

### FAMILY ARDEIDÆ.

**ARDEA HERODIAS**, L.—*Great Blue Heron.*

Was observed along the Yellowstone in some numbers.

Although belonging to the class of water birds, the great blue heron frequently forgets himself and perches on the highest treetop, and there keeps a sharp lookout for danger, so that it is almost impossible to approach sufficiently close for a shot on such occasions.

### FAMILY GRUIDÆ.

**GRUS CANADENSIS**, (L.), Temm.—*Sandhill Crane.*

Seen during the spring migration of 1878 by Colonel Brackett at Fort Custer, Mont.; occurs in this region only at those times.

### FAMILY RALLIDÆ.

**FULICA AMERICANA**, Gm.—*Coot.*

A few are found in the sloughs and ponds through the region traveled.

## ORDER LAMELLIROSTRES.

### FAMILY ANATIDÆ.

**CYGNUS BUCCINATOR**, Sw.—*Trumpeter Swan.*

A single specimen of this swan was killed in the Big Horn region, near Fort C. F. Smith, about December 10, 1877, by Colonel Buell, and identified by Colonel Brackett. Occurs only during the migrations, and at the late date the above specimen was killed there was still, probably, open water in the vicinity.

**BRANTA CANADENSIS**, L.—*Canada Goose.*

While ascending the Missouri and Yellowstone Rivers, many flocks of the Canada goose were observed. It breeds along both rivers in numbers, especially on the Yellowstone, where flocks were seen, the end of July, consisting of the parents and young birds. On these occasions the mother would walk in front with her head down, as if trying to hide herself, the little ones following, and the old male bringing up the rear with his head erect, and viewing the source of danger with apparent great unconcern.

I found it quite common in the vicinity of Fort Custer.

**ANAS BOSCHAS**, L.—*Mallard Duck.*

Is found along the Yellowstone River and throughout the Big Horn region, though it is not particularly common. Breeds wherever found.

Specimen No. 685 ♂ measures as follows: 37.00 × 17.75; wing, 11.80; tail, 4.00.

**DAFILA ACUTA**, (L.), Jenyns.—*Pintail Duck.*

Is found in the Big Horn region in the streams and pools, but not in any great numbers. Breeds throughout its range.

Specimen No. 679 ♂ measures as follows: 36.30 × 24.00; wing, 10.50; tail, 4.50.

**CHAULELASMUS STREPERUS**, Linn.—*Gadwall.*

Is not common, but I saw a few on the road from Custer to Fort Ellis, Montana, in September.

**QUERQUEDULA CAROLINENSIS**, Gm.—*Green-winged Teal.*

Is found in small numbers in this region, where it breeds.

No. 620 ♂ measures as follows: 23.00×15.00; wing, 7.75; tail, 3.24.

**QUERQUEDULA DISCORS** (L.), Steph.—*Blue-winged Teal.*

A few blue-winged teal were seen on the Yellowstone River above Fort Keogh, Montana, as also on the Little Horn, near Fort Custer. Is not common. Breeds here.

Specimen No. 680 ♂ measures as follows: 24.75×15.90; wing, 7.25; tail, 3.10.

**AIX SPONSA** (L.), Boie.—*Wood Duck.*

Captain Mix, Second Cavalry, informed me that he had occasionally during the spring and fall taken this duck at Fort Custer.

**BUCEPHALA CLANGULA** (L.), Gr.—*Golden-eyed Duck.*

Several were seen in a pond on the road from Fort Custer to Fort Ellis. Is not, I believe, common.

**MERGUS MERGANSER** (L.)—*Goosander.*

This duck is found in small numbers in the streams running into the Yellowstone River above Terry's Landing, M. T.

## ORDER LONGIPENNES.

### FAMILY LARIDÆ.

**LARUS DELAWARENSIS**, Ord.—*Ring-billed Gull.*

While ascending the Yellowstone River, and near the mouth of the Big Horn, in August, some gulls were seen in one of the chutes of the river, which, although no specimen was procured, I place under this head, as it is the species most likely to be found there.

## ORDER PYGOPODES.

### FAMILY PODICIPIDÆ.

**PODILYMBUS PODICEPS** (L.), Lawr.—*Pied-billed Grebe.*

Occurs in small numbers in the streams of the Big Horn region.

Specimen No. 675 ♀ measures 20.75×12.00; wing, 5.10.

*Recapitulation of species treated.*

MAMMALS.

| Families. | Number of species. | Families. | Number of species. |
|---|---|---|---|
| Felidæ | 3 | Vespertilionidæ | 1 |
| Canidæ | 7 | Soricidæ | 2 |
| Mustelidæ | 6 | Zapodidæ | 1 |
| Procyonidæ | 1 | Muridæ | 7 |
| Ursidæ | 2 | Geomyidæ | 1 |
| Bassarididæ | 1 | Sciuridæ | 6 |
| Bovidæ | 1 | Castoridæ | 1 |
| Ovidæ | 2 | Hystricidæ | 1 |
| Antilocapridæ | 1 | Leporidæ | 2 |
| Cervidæ | 2 | | |
| | | Total | 48 |

BIRDS.

| Families. | Number of species. | Families. | Number of species. |
|---|---|---|---|
| Turdidæ | 6 | Alcedinidæ | 1 |
| Saxicolididæ | 1 | Picidæ | 6 |
| Cinclidæ | 1 | Strigidæ | 3 |
| Paridæ | 2 | Falconidæ | 7 |
| Sittidæ | 1 | Cathartidæ | 1 |
| Troglodytidæ | 2 | Columbidæ | 1 |
| Alaudidæ | 1 | Tetraonidæ | 4 |
| Motacillidæ | 1 | Charadriidæ | 3 |
| Sylvicolidæ | 3 | Recurvirostridæ | 1 |
| Hirundinidæ | 4 | Phalaropodidæ | 1 |
| Ampelidæ | 1 | Scolopacidæ | 5 |
| Vireonidæ | 1 | Ardeidæ | 1 |
| Laniidæ | 1 | Gruidæ | 1 |
| Fringillidæ | 12 | Rallidæ | 1 |
| Icteridæ | 6 | Anatidæ | 10 |
| Corvidæ | 4 | Laridæ | 1 |
| Tyrannidæ | 4 | Podicipidæ | 1 |
| Caprimulgidæ | 2 | | |
| Trochilidæ | 1 | Total | 102 |

# APPENDIX TT.

## ANNUAL REPORT OF LIEUTENANT CARL F. PALFREY, CORPS OF ENGINEERS, FOR THE FISCAL YEAR ENDING JUNE 30, 1879.

### EXPLORATIONS AND SURVEYS IN THE DIVISION OF THE PACIFIC.

ENGINEER OFFICE, HEADQUARTERS MILITARY DIVISION
OF THE PACIFIC, AND DEPARTMENT OF CALIFORNIA,
PRESIDIO OF SAN FRANCISCO, CAL., *August* 19, 1879.

SIR: I have the honor to submit the following report of this office, for the fiscal year ending June 30, 1879:

*Personnel.*—The office was under the charge of Capt. John H. Coster, Eighth Cavalry, A. D. C., until September 16, 1878, at which date I relieved him per Special Orders No. 142, Headquarters Military Division of the Pacific and Department of California.

Three topographical assistants enlisted in the general service United States Army, have been employed up to April 30; since that date two. It is proposed to fill the complement of four, when the accommodations of the office admit of working to a better advantage.

First Lieut. R. H. Fletcher, Twenty-first Infantry, acting aid-de-camp to Brig. Gen. O. O. Howard, during the campaign against the Nez Percé Indians, has been engaged in preparing a map of the Department of the Columbia, illustrating that campaign, and has assisted in the office work.

The following maps have been prepared during the year:

1st. Projections. Outline map of military division of the Pacific to accompany "descriptions of posts."

Corrections of photographic sheets map of northwestern Territories, from the Office of the Chief of Engineers, United States Army.

Projection only, for western sheet map of military division of the Pacific—scale 12 miles to one inch.

Scout maps, plotted from field-notes or traced from field-maps, checked where practicable, by instrumental surveys and earlier scouts.

In some instances several scouts are combined in one map, in which case, plotting upon projection and checking by astronomical stations have been possible.

Map of Steen Mountains and vicinity, showing the seat of the Bannock Indian War compiled from field-notes taken in 1860 by Major Steen, and Captain Porter in 1864.

Map of the headwaters of Salmon River, Idaho Territory, compiled from field-notes of Lieut. George S. Wilson, Twelfth Infantry.

Map of the vicinities of the Military Posts of Forts Gaston, Klamath, McDermit, Boisé Hall, and Camps Bidwell, Halleck, embracing a number of scouts, called for in a communication from the Chief of Engineers, United States Army.

Maps and tracings of the following reconnaissances:

| From— | To— | By whom. |
|---|---|---|
| Fort Gaston ........ | Witchpeck and return by Red Cap Trail...... | Lieut. James Halloran, Twelfth Infantry. |
| Fort Gaston ........ | Stone Lagoon.................................. | Capt. E. B. Savage, Eighth Infantry. |
| San Diego .......... | Pine Valley Yoabel, Temecula, San Margarito River and return along ocean. | Lieut. John Pitcher, First Cavalry. |
| San Diego .......... | San Bernardino via Tye Valley and San Gorgonio Pass and return, via Temecula. | Lieut. John Pitcher, First Cavalry. |
| Camp Independence | Reno, Nev .................................. | Capt. C. C. C. Car, First Cavalry. |

*Maps and tracings*—Continued.

| From— | To— | By whom. |
|---|---|---|
| Camp Independence | Visalia | Lieut. Wotherspoon, Twelfth Infantry. |
| Camp Independence | Tuolumne River | Capt. A. B. MacGowan, Twelfth Infantry. |
| Camp Independence | Caliente | Do. |
| Camp Independence | Salinas Valley | Lieut. Wotherspoon, Twelfth Infantry. |
| Fort Hall | Lemhi Agency | Lieut. Geo. S. Wilson, Twelfth Infantry. |
| Fort Hall | Salmon City to the headwaters of Salmon River | Lieut. Geo. S. Wilson, Twelfth Infantry. |

## ARCHITECTURAL DRAWINGS AND PLANS OF POSTS.

Plans, estimates, and working drawings, for the alterations of barracks and mess-rooms to headquarter offices, of building occupied by engineer office and officers quarters, have been prepared chiefly under the direction of Captain Coster.

The following plans of posts have been received and traced for photographic copying, or reduced to scale:

Post and buildings at Fort Vancouver, Washington Territory.
Post and buildings at Fort Klamath, Oregon.
Post and buildings at Fort Townsend, Washington Territory.
Post and buildings at Fort Canby, Washington Territory.
Post and buildings at Camp Howard, Indian Territory.
Post and buildings at Camp Huachuca, Arizona Territory.
Post and buildings at Camp John A. Rucker, Arizona Territory.
Post and buildings at Fort Mojave, Arizona Territory.

## PHOTOGRAPHY AND TRACINGS FOR PHOTOGRAPHIC REPRODUCTION.

Lieutenant Fletcher's map has been traced, and copies prepared for use in field and for supply of offices.

Photographic copies of scout-maps have been sent to posts at which they are likely to prove useful.

Drawings not immediately connected with this office have been made and reproduced for the use of other offices at these headquarters.

Number of sheets printed, 796.

Owing to the want of suitably convenient out of door appliances and the insufficient protection against wind and dust afforded by the building occupied by this office, I have been obliged to give up the finer silver process and adopt exclusively the coarser method with prussiate of potash. This work has been urged to the utmost, but the results are much less than could have been obtained with more convenient accommodations.

## SURVEYS, ETC.

A survey was made (July, 1878) of the boundaries of the Marine Hospital Reservation, by Lieutenant Fletcher.

Examination and report upon the water-supply of the Presidio of San Francisco and Post at Point San José.

Location and grading of road connecting Presidio and Fort Point.

Examination and report upon boundary of Military Reservation at Monterey, Cal., as surveyed by Deputy-Surveyor Foreman.

Examination and report upon Hay Reservation of Camp McDermit, Nevada, as laid out by Deputy-Surveyor Van Lennep.

Re-survey and location of displaced corner-post of Fort Halleck, Nevada.

Instrumental work has been done at various times in connection with work of the Quartermaster's Department (roads and water-supply) at this post.

The funds at the disposal of this office have not admitted of any field-work not immediately connected with questions of boundaries.

The office work, both draughting and photographic, has been materially interfered with by the bad condition of the building occupied, and the continual expectation of thorough repairs which would require a removal of the office material.

The diminution of the pay of topographical assistants by the withdrawal of their commutation of quarters ($20 per month) and reduction of fuel allowance of $9.91 per month has occasioned much hardship, and renders it exceedingly difficult to secure suitable men for the compensation now offered.

A list of reports of scouts received during the fiscal year is appended.

I have the honor to be, very respectfully, your obedient servant,

CARL F. PALFREY,
*First Lieutenant of Engineers, U. S. A.,*
*Engineer Officer.*

The CHIEF OF ENGINEERS, U. S. A.

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LIST OF REPORTS OF SCOUTS RECEIVED AT ENGINEER OFFICE, HEADQUARTERS MILITARY DIVISION OF THE PACIFIC AND DEPARTMENT OF CALIFORNIA DURING THE FISCAL YEAR ENDING JUNE 30, 1879.

| From— | To— | By Whom. |
|---|---|---|
| Fort Gaston | Mining district of Mill Creek, via Witchpeck and return, via Red Cap Trail. | Lieut. James Halloran. |
| Fort Gaston | Stone Lagoon | Capt. E. B. Savage, Eighth Infantry. |
| Fort Hall | Lemhi Agency, I. T | Lieut. Geo. S. Wilson. |
| Lemhi Agency | Headwaters of Salmon River, I. T. | Do. |
| Fort McDermit | Catlow's Valley | Sergeant P. Stone, Eighth Infantry. |
| Fort Gaston | Itinerary from Fort Gaston to Arcata as measured by odometer. | |
| Fort McDermit | Scout from Fort McDermit to Owyhee River, 178 miles. | Lieut. J. W. Summerhayes, Eighth Infantry. |
| Fort McDermit | Scout from Fort McDermit to beyond Steen Mountains, 313 miles. | Lieut. J. W. Summerhayes, Eighth Infantry. |

# INDEX.

| SUBJECT. | Page. | | | |
|---|---|---|---|---|
| | Part I. | | Part II. | Part III. |
| **A.** | | | | |
| Accotink Creek, Va., improvement of | 83 | 601 | | |
| Ahnepee Harbor, Wis., improvement of | 153 | | 1505 | |
| Alabama River, improvement of | 103 | 827 | | |
| Alexandria, Mo., examination of Mississippi River at | 133 | | 1159 | |
| Allegheny River, Pa., improvement of | 144 | | | |
| Allegheny River, survey of, to mouth of French Creek | 147 | | 1371 | |
| Allegheny River, to Olean, N. Y., examination and survey of | 147 | | | |
| Alsea Harbor, Oreg., and bar in front of it, examination and survey of | 183 | | | |
| Alsea River and Bay, Oreg., examination of | 183 | | 1810 | |
| Alton Harbor, Ill., examination and survey of | 120 | | | |
| Anguille River, Ark., improvement of | 115 | | 969 | |
| Annapolis Harbor, Md., survey of bars at entrance to | 81 | 574 | | |
| Apalachicola Bay, Fla., examination of | 106 | 823 | | |
| Apalachicola River, improvement of | 103 | 821 | | |
| Appomattox River, Va., improvement of | 78 | 521 | | |
| Approaches from Lake Superior to Saint Mary's Falls Ship Canal, examination and survey of, for a 16-foot channel | 168 | | | |
| Aquia Creek, Va., improvement of | 84 | 603 | | |
| Aransas Pass and Bay, Tex., improvement of | 111 | 928 | | |
| Aransas Pass and Bay, Tex., examination of | 112 | 928 | | |
| Archer's Hope River, Va., examination and survey of | 95 | | | |
| Arkansas, Missouri, and Mississippi Rivers, operations of snagboats on | 120 | | 1049 | |
| Arkansas River, at Fort Smith, Ark., improvement of | 126 | | 1081 | |
| Arkansas River, at Pine Bluff, examination and survey of | 127 | | | |
| Arkansas River, improvement of, above Fort Smith, Ark. | 125 | | 1081 | |
| Arkansas River, from Fort Smith to mouth of Little Arkansas, examination of | 127 | | 1085 | |
| Aroostook River, Me., examination and survey of | 52 | | | |
| Ashland Harbor, Wis., examination and survey of | 155 | | | |
| Ashtabula Harbor, Ohio, improvement of | 173 | | 1700 | |
| Atchison, Kans., improvement of Missouri River at | 123 | | 1063 | |
| Au Sable River Harbor, Mich., improvement of | 169 | | 1657 | |
| **B.** | | | | |
| Baltimore Harbor, pier and bulkhead lines, report on | 76 | 497 | | |
| Baltimore Harbor, improvement of entrance to | 76 | 492 | | |
| Barren River, Ky., examination and survey of | 147 | | | |
| Bath, Me., improvement at the gut opposite | 45 | 252 | | |
| Battalion of Engineers | 39 | | | |
| Bar at mouth of Bell River, Mich., examination and resurvey of | 170 | | | |
| Bay of Superior, improvement of natural entrance to | 150 | | 1468 | |
| Bayfield Harbor, Wis., examination and survey of | 155 | | | |
| Bayou Bartholomew, Ark., examination of | 118 | | 997 | |
| Bayou Courtableau, La., examination and survey of | 112 | | | |
| Bayou Deglaize, La., examination and survey of | 112 | | | |
| Bayou La Fourche, La., improvement of | 107 | 900 | | |
| Bayou Pierre, La., examination of | 118 | | 991 | |
| Bayou Teche, La., examination and survey of | 112 | | | |

# INDEX.

| SUBJECT. | Page. | | |
|---|---|---|---|
| | Part I. | Part II. | Part III. |
| Bayou Terrebonne, La., examination and survey of.... | 112 | | |
| Bayou Vermillion, La., examination and survey of.... | 112 | | |
| Bayou Wincey, La., examination of.................... | 118 | 991 | |
| Bell River, Mich., bar at mouth of, resurvey of.......... | 170 | | |
| Belfast Harbor, Me., improvement of.................... | 45 250 | | |
| Benton Harbor Channel of Saint Joseph River, Mich., examination and survey of.................... | 167 | | |
| Bergen Neck, N. J., survey for ship canal across......... | 66 | | |
| Big Sandy River, W. Va. and Ky., improvement of.... | 145 | 1353 | |
| Big Sunflower River, Miss., examination of............ | 117 | 982 | |
| Big Sunflower River, Miss., improvement of ............ | 116 | 970 | |
| Black Lake Harbor, Mich., improvement of............ | 164 | 1622 | |
| Black River Harbor, Ohio, improvement of............ | 172 | 1674, 1689 | |
| Black River, Ark., examination and survey of.......... | 118 | | |
| Black Warrior River, Ala., improvement of ............ | 104 830 | | |
| Blackwater River, Va., improvement of................ | 90, 620, 682 | | |
| Block Island, R. I., construction of harbor at ............ | 55 311 | | |
| Bloody Island, examination of Mississippi River at..... | 120 | 1024, 1045 | |
| Board of engineers for fortifications.................... | 33 | | |
| Board of engineers, on improvement of low-water navigation of the Mississippi and Missouri rivers ........ | 43 | 1007 | |
| Boston Harbor, Mass., improvement of.................. | 49 267 | | |
| Breton Bay, Md., improvement of...................... | 83 600 | | |
| Brazos River and Bar, Tex., examination of............ | 111 938 | | |
| Brazos Santiago, Tex., removing obstructions at ....... | 111 919 | | |
| Breakwater at Mackinac, Mich., examination and survey of.................................... | 170 | | |
| Breakwater at Cleveland, Ohio, construction of......... | 172 | 1691 | |
| Breakwater, near New Orleans, La., estimate for, and survey of.................................... | 112 | | |
| Broadkiln River, Del., improvement of................. | 73 445 | | |
| Bridge over the Mississippi River at Rock Island, sheer-booms for piers of ............................ | 132 | 1144 | |
| Bridges over the Ohio River ........................... | 149 | 1463 | |
| Bridging navigable waters of the United States....... | 149 | 1461 | |
| Bridgeport Harbor, Conn., improvement of ............ | 58 349 | | |
| Broad River, S. C., examination and survey of ........ | 100 | | |
| Broad Creek, examination and survey of.............. | 81 | | |
| Broad Bay, Va., examination and survey of............ | 95 | | |
| Brunswick Harbor, Ga., improvement of................ | 98 765 | | |
| Buffalo Harbor, N. Y., improvement of................ | 174 | 1717 | |
| Bulkhead Rock, Providence River, R. I., removal of... | 54 307 | | |
| Burlington, Iowa, improvement of harbor at........... | 131 | 1138 | |
| Burlington Harbor, Vt., improvement of................ | 65 395 | | |

C.

| | | | |
|---|---|---|---|
| Cabin Creek, Md., examination of channel to.......... | 81 | | |
| Cahokia Chute, Mississippi River, opposite Saint Louis, closing of.............................. | 118 | 1027 | |
| Calumet Harbor, Ills., improvement of................ | 158 | 1567 | |
| Caloosahatchie River, Fla., examination of............ | 106 863 | | |
| Cambridge Harbor, Md., improvement of.............. | 76 500 | | |
| Campaigns and battle-fields, preparation of maps of... | 185 | | |
| Canal, Louisville and Portland, superintendence and management of.............................. | 143 | 1284 | |
| Canal at Des Moines Rapids, Mississippi River......... | 133 | 1151 | |
| Canal, Saint Mary's River, Fla., and Gulf of Mexico, survey for.............................. | 99 | | |
| Canal, Saint Mary's Falls, Mich., construction of....... | 167 | 1641 | |
| Canal at the Cascades, Columbia River, Oreg., construction of.............................. | 181 | 1790, 1843 | |
| Canal around the Dalles, Columbia River, Oreg., examination and survey for.............................. | 183 | | |
| Canal to connect Delaware and Chesapeake Bays, survey for.............................. | 81 587 | | |

# INDEX.

| Subject. | Page. Part I. | Page. Part II. | Page. Part III. |
|---|---|---|---|
| Canal connecting Galveston and Brazos River, Tex., survey for | 112 | | |
| Canarsie Bay, N. Y., examination of | 66 400 | | |
| Caney Fork, Tenn., examination of | 142 | 1275 | |
| Caney Fork, Tenn., examination and survey of | 142 | | |
| Cape Fear River, N. C., improvement of entrance to | 80 556 | | |
| Cape Foulweather, Oreg., examination of, for harbor of refuge | 183 | 1796 | |
| Cathanse, Maine, examination and survey of | 52 | | |
| Catawba River, N. C. and S. C., for survey of | 95 | | |
| Cedar City, Mo., examination of Missouri River at | 121 | 1053 | |
| Cedar Keys Harbor, Fla., improvement of | 101 812 | | |
| Channel between Staten Island and New Jersey, improvement of | 64 392 | | |
| Charles River, Mass., survey of | 52 290 | | |
| Charleston Harbor, S. C., improvement of | 95 731 | | |
| Charlevoix Harbor, Mich., improvement of | 161 | 1595 | |
| Charenton Canal, Saint Mary's Parish, La., survey for | 112 | | |
| Charlotte Harbor, N. Y., improvement of | 175 | 1727 | |
| Charlotte Harbor and Peas Creek, Fla., examination and survey of | 106 | | |
| Chattahoochie River, Ga., above Columbus, survey of | 142 | | |
| Chattahoochie River, Ala. and Ga., improvement of | 101 814 | | |
| Cheboygan Harbor, Mich., improvement of | 169 | 1666 | |
| Cheesequakes Creek, N. J., examination and survey of | 66 | | |
| Chester Harbor, Pa., ice-harbor at | 72 443 | | |
| Chester River, Md., improvement of, at Kent Island Narrows | 75 489 | | |
| Cheyenne River, Dak., examination and survey of | 128 | | |
| Chicago Harbor, Ill., improvement of | 157 | 1555 | |
| Chickahominy River, Va., improvement of | 86 619 | | |
| Chicasaha River, Miss., examination of | 105 841 | | |
| Chincoteague Inlet, Va., examination and survey of | 81 | | |
| Chippewa River, Wis., improvement of | 135 | 1168 | |
| Choctawhatchie River, Ala., examination and survey of | 106 | | |
| Choctawhatchie River, Fla. and Ala., improvement of | 103 824 | | |
| Choptank River, Md., examination and survey of | 81 | | |
| Chowan River, N. C., survey of | 95 726 | | |
| Cincinnati, Ohio, ice-harbor at | 146 | 1355 | |
| Clearwater River, Idaho, examination and improvement of | 182 | 1855 | |
| Cleveland Harbor, Ohio, improvement of | 172 | 1691 | |
| Clinton River, Mich., resurvey of | 170 | | |
| Cocheco River, N. H., improvement of | 47 260 | | |
| Cohansey Creek, N. J., improvement of | 68 414 | | |
| Cold Water River, Miss., improvement of | 116 | 970 | |
| Cold Water River, Miss., examination of | 118 | 984 | |
| Colorado of the West, survey of | 180 | 1773 | |
| Columbia River, Oreg., improvement of mouth of | 182 | 1791, 1853 | |
| Columbia River, Lower, Oreg., improvement of | 180 | 1787, 1825 | |
| Columbia River at the Dalles, Oreg., &c., examination and survey of | 183 | | |
| Columbia River, Upper, and Snake River, Oreg., improvement of | 181 | 1789, 1839 | |
| Columbia River, Oreg., canal at Cascades | 181 | 1790, 1843 | |
| Columbia River, survey of bar at mouth of | 183 | 1863 | |
| Conecuh River, Ala., examination of | 106 843 | | |
| Conemaugh River, Pa., examination of | 147 | 1388 | |
| Conneaut Harbor, Ohio, improvement of | 173 | 1705 | |
| Connecticut River, above Hartford, Conn., improvement of | 56 319 | | |
| Connecticut River, below Hartford, Conn., improvement of | 55 316 | | |
| Coos Bay, Oreg., improvement of | 182 | 1791, 1854 | |

| Subject. | Page. | | | |
|---|---|---|---|---|
| | Part I. | | Part II. | Part III. |
| Coos Bay, Oreg., examination of | 182 | | 1791 | |
| Coosa River, Ga. and Ala., improvement of | 140 | | 1269 | |
| Coosa River to Wetumpka, Ala., examination and survey of | 106 | | | |
| Coosawattee River, Ga., improvement of | 141 | | 1271 | |
| Coquille River, Oreg., survey of | 183 | | 1806 | |
| Council Bluffs, Iowa, improvement of Missouri River at | 124 | | 1076 | |
| Corpus Christi Pass and Channel, Tex., examination of | 112 | 928 | | |
| Cowlitz River, Wash., &c., examination and survey of | 183 | | | |
| Crescent City Harbor, Cal., examination of | 180 | | 1785 | |
| Cuivre River, Mo., examination and survey of | 133 | | | |
| Cumberland River, Ky., survey of falls of | 142 | | 1279 | |
| Cumberland River, Tenn., improvement of | 138 | | 1264 | |
| Cumberland Sound, Fla. and Ga., entrance to, improvement of | 99 | 792 | | |
| Currituck Sound, improvement of | 90 | 693 | | |
| Cypress Bayou, Tex., improvement of | 113 | | 957 | |

D.

| | | | | |
|---|---|---|---|---|
| Dan River, Va., examination of | 88 | 652 | | |
| Dan River, Va., from Clarksville, Va., to Danbury, N. C., examination and survey of | 88 | | | |
| Darien Harbor, Ga., improvement of | 97 | 763 | | |
| Davis' Island, Ohio River, movable dam at | 143 | | 1299 | |
| Defenses, sea-coast and lake-frontier | 4 | | | |
| Deglaize Bayou, La., examination and survey of | 112 | | | |
| Delaware Breakwater Harbor | 74 | 453 | | |
| Delaware River: | | | | |
| at Cherry Island Flats, improvement of | 71 | 436 | | |
| at Chester and Marcus Hook, Pa., examination and survey of | 75 | | | |
| at Schooner Ledge, improvement of | 71 | 433 | | |
| below Bridesburg, Pa., improvement of | 70 | 423 | | |
| below League Island, survey of | 75 | 485 | | |
| between Trenton and White Hill, N. J., improvement of | 69 | 420 | | |
| Des Moines Rapids Canal, Mississippi River | 133 | | 1151 | |
| Detroit River, Mich., improvement of | 168 | | 1650 | |
| Dubuque, Iowa, improvement of harbor at | 132 | | 1140 | |
| Duck Creek, Del., examination of | 75 | 470 | | |
| Duck River to Centreville, Tenn., examination and survey of | 142 | | | |
| Duluth Harbor, Minn., improvement of | 149 | | 1465 | |
| Dunkirk Harbor, N. Y., improvement of | 174 | | 1715 | |
| Duties and rank of officers of the Corps of Engineers | 191 | | | |

E.

| | | | | |
|---|---|---|---|---|
| Eagle Harbor, Mich., improvement of | 151 | | 1480 | |
| East Chester Creek, N. Y., improvement of | 63 | 388 | | |
| East River, N. Y., removal of obstructions from | 61 | 375 | | |
| Echo Harbor, New Rochelle, N. Y., improvement of | 63 | 389 | | |
| Edenton Harbor, N. C., improvement of | 91 | 696 | | |
| Elk River, W. Va., improvement of | 80 | 555 | | |
| Elizabeth River, N. J., examination of | 75 | 481 | | |
| Elizabeth River, N. J., improvement of | 67 | | | |
| Elizabeth River, Va., improvement of south branch of | 89 | 679 | | |
| Engineer-depots | 39 | | | |
| Entrance to Cumberland Sound, Fla. and Ga., improvement of | 99 | 792 | | |
| Erie Harbor, Pa., improvement of | 173 | | 1707 | |
| Escambia River, Ala. and Fla., examination of | 106 | 852 | | |
| Etowah River, Ga., improvement of | 141 | | 1272 | |
| Etowah River, Ga., examination of | 142 | | | |

| Subject. | Page. | | |
|---|---|---|---|
| | Part I. | Part II. | Part III. |
| Explorations, geological, &c., 40th parallel, completion of | 186 | | |
| Explorations, geographical, &c., west of 100th meridian | 186 | | 1977 |
| Explorations and reconnaissances | 188 | | |
| Explorations and surveys in Division of the Missouri | 188 | | 2315 |
| Explorations and surveys in Department of the Platte | 188 | | 2319 |
| Explorations and surveys in Department of the Missouri | 189 | | 2329 |
| Explorations and surveys in Department of Dakota | 189 | | 2359 |
| Explorations and surveys in Division of the Pacific | 189 | | 2397 |
| Explorations and reconnaissances, estimates for | 190 | | |
| **F.** | | | |
| Fairport Harbor (Grand River), Ohio, improvement of | 173 | 1698 | |
| Falls of the Cumberland River, Ky., survey of | 142 | 1279 | |
| Falls of Saint Anthony, Minn., preservation of | 134 | 1159 | |
| Falls of the Ohio River, improvement of navigation at | 143 | 1283 | |
| Feather and Sacramento rivers, Cal., improvement of | 178 | 1749 | |
| Flint River, Ga., improvement of | 102 817 | | |
| Flint River, Ga., survey of Upper | 105 818 | | |
| Flushing Bay, N. Y., examination of | 66 387 | | |
| Flushing Bay, N. Y., improvement of | 62 385 | | |
| Fort Columbus, New York Harbor, sea-wall at Governor's Island | 15 233 | | |
| Fort Delaware, damage by storms at | 19 241 | | |
| Fort Leavenworth, Kans., improvement of Missouri River at | 122 | 1063 | |
| Fort Madison, Iowa, improvement of harbor at | 132 | 1139 | |
| Fort Mifflin, Delaware River, damage by storms at | 19 237 | | |
| Fort Smith, Ark., improvement of Arkansas River at | 126 | 1081 | |
| Fortifications | 8 233 | | |
| Fourche la Fève, Ark., examination of | 118 | 971 | |
| Fourche la Fève, Ark., improvement of | 116 | 971 | |
| Fox and Wisconsin rivers, improvement of | 156 | 1531 | |
| Frankfort Harbor, Mich., improvement of | 161 | 1601 | |
| French Broad River, N. C., improvement of | 87 648 | | |
| **G.** | | | |
| Galena River and Harbor, Ill., improvement of | 132 | 1146 | |
| Galveston Bay, ship-channel in, improvement of | 110 912 | | |
| Galveston Harbor, Tex., improvement of entrance to | 109 909 | | |
| Gasconade River, Mo., examination and survey of | 127 | | |
| Geographical explorations and surveys west of 100th meridian | 186 | | 1977 |
| Geological exploration 40th parallel, completion of | 186 | | |
| Georgetown and Washington Harbors, D. C., improvement of | 82 591 | | |
| Glasgow, Mo., improvement of Missouri River at | 121 | 1055 | |
| Grand Haven Harbor, Mich., improvement of | 164 | 1618 | |
| Grand Marias, Minn., improvement of harbor at | 150 | 1475 | |
| Grand River (Fairport) Harbor, Ohio, improvement of | 173 | 1698 | |
| Great Kanawha River, W. Va., improvement of | 79 545 | | |
| Great Sodus Harbor, N. Y., improvement of | 176 | 1729 | |
| Green Bay Harbor, Wis., improvement of | 152 | 1486 | |
| Green River, Ky., examination and survey of | 147 | | |
| Guyandotte River, W. Va., improvement of | 145 | 1347 | |
| **H.** | | | |
| Hampton River, Va., improvement of | 85 617 | | |
| Harbor of refuge at Portage Lake, survey and improvement of | 166 | 1634 | |
| Harbor of refuge, Lake Huron | 167 | 1645 | |

| Subject. | Page. Part I. | Page. Part II. | Page. Part III |
|---|---|---|---|
| Harbor of refuge near Cincinnati, Ohio, construction of | 146 | 1355 | |
| Harbor of refuge entrance to Portage Lake, and Lake Superior ship-canal, examination and survey of | 155 | | |
| Harbor of refuge, Sturgeon Bay Canal, Wis., construction of | 152 | 1488 | |
| Harlem River, N. Y., improvement of | 62 385 | | |
| Hell Gate, N. Y., improvement of navigation at | 61 375 | | |
| Hiawassee River, Tenn., improvement of | 140 | 1268 | |
| Hillsborough River, Fla., examination of mouth of | 106 870 | | |
| Housatonic River, Conn., improvement of | 58 344 | | |
| Hudson River, N. Y., improvement of | 60 367 | | |
| Humboldt River, Cal., examination of | 180 | 1785 | |
| Huron Harbor, Ohio, improvement of | 171 | 1673, 1686 | |
| Hyannis Harbor, Mass., improvement of | 52 295 | | |

**I.**

| Subject. | Part I. | Part II. | Part III |
|---|---|---|---|
| Ice harbor at Cincinnati, Ohio, construction of | 146 | 1355 | |
| Ice harbor at mouth of Muskingum River | 146 | 1364 | |
| Illinois River, improvement of | 158 | 1569 | |
| Illinois River, examination and survey of | 160 | | |
| Inside passage between Fernandina and Saint John's River, Fla., improvement of | 98 765 | | |

**J.**

| Subject. | Part I. | Part II. | Part III |
|---|---|---|---|
| James River, Va., improvement of | 77 512 | | |
| Jonesport, Me., examination of Moosebeck Bar at | 52 | | |
| Jetties at mouth of Saint John's River, Fla., project for | 98 767 | | |

**K.**

| Subject. | Part I. | Part II. | Part III |
|---|---|---|---|
| Kanawha River, Great, improvement of | 79 545 | | |
| Kanawha River, Little, improvement of | 145 | 1346 | |
| Kankakee River, Ill. and Ind., survey of | 148 | 1455 | |
| Kansas River, examination of Missouri River at mouth of | 122 | 1059 | |
| Kansas River, Kans., examination of | 127 | 1089 | |
| Kansas City, Mo., improvement of Missouri River at | 122 | 1059 | |
| Kennebunk River, Me., improvement of | 47 259 | | |
| Kenosha Harbor, Wis., improvement of | 156 | 1529 | |
| Kent Island Narrows, Md., improvement of | 75 489 | | |
| Kentucky River, Ky., survey of | 147 | 1398 | |
| Kentucky River, Ky., improvement of | 146 | | |
| Kiskiminetas River, Pa., examination of | 147 | 1388 | |

**L.**

| Subject. | Part I. | Part II. | Part III |
|---|---|---|---|
| La Crosse, Wis., improvement of Mississippi River at | 130 | 1127 | |
| Lake Bayou Pierre, La., examination of | 118 | 991 | |
| Lake Cannasanier, La., examination of | 118 | 991 | |
| Lake harbors and rivers | 149 | 1465 | |
| Lakes, Northern and Northwestern, survey of | 194 | | 1891 |
| L'Anguille River, Ark., improvement of | 115 | 969 | |
| Laws of Forty-fifth Congress, third session, and of Forty-sixth Congress, first session, affecting Corps of Engineers | 209 | | |
| Levees on the Mississippi River, report on the effect of a continuous system for | 43 | 1015 | |
| Leonardtown Harbor, Md., improvement of | 83 600 | | |
| Lewes, Del., construction of piers at | 73 445 | | |
| Licking River, Ky., examination of | 147 | 1422 | |
| Lincolnville Harbor, Me., survey of | 52 275 | | |
| Lin Haven Bay, Va., examination and survey of | 95 | | |

# INDEX.

| Subject. | Page. Part I. | Page. Part II. | Page. Part III. |
|---|---|---|---|
| Link Horn Bay, Va., examination and survey of | 95 | | |
| Little Kanawha River, W. Va., improvement of | 145 | 1346 | |
| Little Kanawha River, mouth of, for ice harbor, examination and survey of | 147 | | |
| Little Narragansett Bay, R. I. and Conn., improvement of | 55 313 | | |
| Little River, Ark., examination of | 118 | 990 | |
| Little Sodus Harbor, N. Y., improvement of | 176 | 1731 | |
| Lockwood's Folly River, N. C., examination and survey of | 95 | | |
| Long Island coast, N. Y., examination of, between Rockaway and Coney Island | 66 399 | | |
| Louisville and Portland Canal, superintendence and management of | 143 | 1284 | |
| Lower Willamette and Columbia rivers, Oreg., improvement of | 180 | 1787, 1825 | |
| Lubec Channel, Me., improvement of | 44 246 | | |
| Lubec Channel, Me., survey of | 52 279 | | |
| Ludington Harbor, Mich., improvement of | 162 | 1606 | |
| **M.** | | | |
| Manasquan River, N. J., examination of | 74 463 | | |
| Manasquan River, N. J., improvement of | 68 | | |
| Manistee Harbor, Wis., improvement of | 162 | | |
| Manitowoc Harbor, Wis., improvement of | 154 | 1603 | |
| Maps, military, geographical, and lake survey, preparation of | 185 | 1516 | |
| Maps of campaigns and battle-fields, report on | 185 | | 1973 |
| Mackinac Breakwater, Mich., examination and survey of | 170 | | |
| Marcus Hook Harbor, Pa., improvement of | 73 444 | | |
| Marquette Harbor, Mich., improvement of | 151 | 1482 | |
| Matagorda Bay, Tex., improvement of entrance to | 111 921 | | |
| Meeker's Island, Minn., lock and dam at | 134 | 1168 | |
| Memphis, Tenn., protection of water front of | 117 | 979 | |
| Menomonee Harbor, Mich. and Wis., improvement of | 152 | 1484 | |
| Merrimac River, Mass., improvement of | 48 264 | | |
| Michigan City Harbor, Ind., improvement of | 160 | 1587 | |
| Milford Harbor, Conn., improvement of | 58 341 | | |
| Milwaukee Harbor, Wis., improvement of | 155 | 1523 | |
| Minnesota River, improvement of | 135 | 1182 | |
| Mispillion Creek, Del., examination of | 75 467 | | |
| Mississippi, Missouri, and Arkansas Rivers, operations of snagboats on | 120 | 1049 | |
| Mississippi River: | | | |
| above the Falls of Saint Anthony, improvement of. | 134 | 1165 | |
| at Alexandria, Mo., examination of | 133 | 1150 | |
| at Bloody Island, examination of | 120 | 1045 | |
| at Burlington, Iowa, improvement of | 131 | 1138 | |
| at Des Moines Rapids, improvement of | 133 | 1151 | |
| at Dubuque, Iowa, improvement of | 132 | 1140 | |
| at Falls of Saint Anthony, improvement of | 134 | 1159 | |
| at Fort Madison, Iowa, improvement of | 132 | 1139 | |
| at La Crosse, Wis., improvement of | 130 | 1127 | |
| at Meeker's Island, improvement of | 134 | 1168 | |
| at Muscatine, Iowa, improvement of | 131 | 1136 | |
| at Quincy, Ill., examination of | 133 | 1130 | |
| at Quincy, Ill., improvement of | 130 | 1130 | |
| at Rock Island Rapids, improvement of | 131 | 1132 | |
| at Venice, Ill., examination of | 120 | | |
| between the mouths of the Illinois and Ohio Rivers, improvement of | 118 | 1023 | |
| from Des Moines Rapids to the mouth of Illinois River, deepening channel of | 130 | 1122 | |

# INDEX.

| SUBJECT. | Page. | | | |
|---|---|---|---|---|
| | Part I. | | Part II. | Part III. |
| Mississippi River: | | | | |
| from Saint Paul to Des Moines Rapids, deepening channel of | 129 | | 1111 | |
| from Saint Paul to Falls of Saint Anthony, examination and survey of | 136 | | | |
| opposite mouth of Missouri, examination and survey of | 120 | | | |
| reservoirs at sources of, survey for | 136 | | 1193 | |
| improvement of low-water navigation of, below Cairo | 43 | | 1007 | |
| report on continuous levee system for | 43 | | 1015 | |
| survey of | 184 | | | 1891 |
| Upper, improvement of, operations of snagboat | 128 | | 1103 | |
| Missouri, Mississippi, and Arkansas Rivers, operations of snagboats on | 120 | | 1050 | |
| Missouri River: | | | | |
| above the mouth of the Yellowstone, improvement of | 127 | | 1094 | |
| at Atchison, Kans., improvement of | 123 | | 1063 | |
| at Cedar City, Mo., examination of | 127 | | 1054 | |
| at Cedar City, Mo., improvement of | 121 | | 1053 | |
| at Fort Leavenworth, Kans., improvement of | 122 | | 1063 | |
| at Glasgow, Mo., improvement of | 121 | | 1055 | |
| at junction of Kansas River, examination of | 127 | | 1059 | |
| at Kansas City, Mo., improvement of | 122 | | 1059 | |
| at Nebraska City, Nebr., improvement of | 124 | | 1066 | |
| at Omaha, Nebr., improvement of | 124 | | 1076 | |
| at Saint Charles, Mo., examination for improvement | 127 | | 1083 | |
| at Saint Joseph, Mo., improvement of | 123 | | 1065 | |
| at Sioux City, Iowa, improvement of | 124 | | 1078 | |
| at Vermillion, Dak., improvement of | 125 | | 1079 | |
| survey of, from its mouth to Sioux City, Iowa | 126 | | 1082 | |
| remarks on improvement of | | | 1051 | |
| Mobile Harbor, Ala., improvement of | 100 | 799 | | |
| Monongahela River, improvement of | 144 | | 1344 | |
| Mount Vernon, Va., improvement of channel at | 83 | 598 | | |
| Monroe Harbor, Mich., improvement of | 170 | | 1669, 1675 | |
| Moosebec Bar, Jonesport, Me., examination and survey of | 52 | | | |
| Morristique River, Mich., examination and survey of | 155 | | | |
| Movable dam at Davis Island, Ohio River | 143 | | 1299 | |
| Movable dam, Upper Fox River, Wis., project for | | | 1547 | |
| Muddy River, Ky., examination and survey of | 147 | | | |
| Muskegon Harbor, Mich., improvement of | 163 | | 1615 | |
| Muskingum River, Ohio, examination of | 147 | | 1364 | |
| Muscatine, Iowa, improvement of harbor at | 131 | | 1136 | |
| **N.** | | | | |
| Nansemond River, Va., improvement of | 89 | 681 | | |
| Nantucket Harbor, Mass., examination and survey of | 56 | | | |
| Narragansett Bay, R. I., improvement of | 54 | 306 | | |
| Nanticoke River, Del. and Md., examination and survey of | 81 | | | |
| Nebraska City, Nebr., improvement of Missouri River at | 124 | | 1066 | |
| Natchez, Miss., protection of harbor at | 118 | | | |
| Neches River, Tex., improvement of | 109 | 905 | | |
| Neches River, Tex., examination and resurvey of | 112 | | | |
| Neuse River, N. C., examination of | 95 | 708 | | |
| Neuse River, N. C., improvement of | 93 | 704 | | |
| New Bedford Harbor, Mass., improvement of | 53 | 303 | | |
| New Buffalo Harbor, Mich., improvement of | 161 | | 1596 | |
| Newburyport Harbor, Mass., improvement of | 48 | 264 | | |

| Subject. | Page. Part I. | Part II. | Part III. |
|---|---|---|---|
| New Castle, Del., ice-harbor at | 71 439 | | |
| New Haven Harbor, Conn., improvement of | 57 335 | | |
| New Orleans, La., improvement of harbor at | 106 876 | | |
| New River, Va. and West Va., improvement of | 79 530 | | |
| New River, Va. and West Va., survey of | 81 538 | | |
| New Rochelle, N. Y., improvement at | 63 389 | | |
| Newtown Creek, N. Y., examination of, at junction with East River | 66 | | |
| Nomini Creek, Va., improvement of | 84 605 | | |
| Norfolk Harbor, Va., improvement of | 88 673 | | |
| Northeast River, Md., examination and survey of | 81 | | |
| North Landing River, Va., examination of | 95 686 | | |
| North Landing River, Va. and N. C., improvement of | 90 683 | | |
| Norwalk Harbor, Conn., improvement of | 59 363 | | |
| North River Bar, Currituck Sound, N. C., improvement of | 90 693 | | |
| Nottoway River, Va., examination and survey of | 95 719 | | |
| Noxubee River, Miss., examination and survey of | 106 | | |
| **O.** | | | |
| Oakland Harbor, San Francisco Bay, Cal., improvement of | 177 | 1742 | |
| Oak Orchard Harbor, N. Y., improvement of | 175 | 1727 | |
| Obey's River, Tenn., examination of | 142 | 1277 | |
| Occoquan River, Va., improvement of | 83 601 | | |
| Ocmulgee River, Ga., improvement of | 141 | 1272 | |
| Oconee River, Ga., improvement of | 142 | 1274 | |
| Oconto River, Wis., examination and survey of | 157 | | |
| Office of the Chief of Engineers | 190 | | |
| Officers of the Corps of Engineers, number of, duties of. | 3 191 | | |
| Ogdensburg Harbor, N. Y., resurvey of | 177 | | |
| Ogdensburg Harbor, N. Y., improvement of | 177 | 1737 | |
| Ohio River and mouth of Little Kanawha River, W. Va., for ice-harbor, &c., examination and survey of. | 147 | | |
| Ohio River, improvement of | 143 | 1299 | |
| Ohio River, improvement of Falls of | 143 | 1283 | |
| Olcott Harbor, N. Y., improvement of | 175 | 1726 | |
| Omaha, Nebr., improvement of Missouri River at | 124 | 1076 | |
| Onancock Harbor, Va., improvement of | 77 510 | | |
| Onancock Harbor, Va., examination of | 95 716 | | |
| Ontonagon Harbor, Mich., improvement of | 151 | 1477 | |
| Oostenaula River, Ga., improvement of | 141 | 1271 | |
| Osage River, Mo. and Kans., improvement of | 119 | 1044 | |
| Oswego Harbor, N. Y., improvement of | 176 | 1732 | |
| Otter Creek, Vt., improvement of | 65 398 | | |
| Ouachita River, Ark. and La., improvement of | 114 | 965 | |
| Outlet of Lake Winnepesaukee, N. H., examination and survey of | 52 | | |
| Outlet to Wolf Lake, Ind., examination and resurvey of. | 160 | | |
| **P.** | | | |
| Pamlico River, N. C., improvement of | 92, 649, 703 | | |
| Pamunkey River, Va., examination and survey of | 95 | | |
| Pascagoula River, Miss., examination of | 105 835 | | |
| Pascagoula River, Miss., improvement of | 105 834 | | |
| Passaic River, N. J., improvement of | 63 391 | | |
| Pass Cavallo, Tex., improvement of | 111 921 | | |
| Patapsco River, Md., improvement of | 76 492 | | |
| Patapsco River, Md., West Branch, survey for improvement of | 81 579 | | |
| Patsaligo River, Ala., examination of | 106 850 | | |
| Pawtucket River, R. I., improvement of | 54 305 | | |
| Pea River, Ala., examination and survey of | 106 | | |

| SUBJECT. | Page. | | | |
|---|---|---|---|---|
| | Part. 1. | | Part II. | Part III |
| Pearl River, Miss., examination of | 111 | 879 | | |
| Pearl River, Miss., improvement of | 107 | 878 | | |
| Pee Dee River, N. C., examination of | 95 | 723 | | |
| Pee Dee River, S. C., examination and survey of | 95 | | | |
| Penobscot River, Me., improvement of | 44 | 247 | | |
| Pensacola Harbor, Fla., improvement of | 100 | 801 | | |
| Pentwater Harbor, Mich., improvement of | 163 | | 1609 | |
| Pere Marquette Harbor, Mich. (see Ludington) | 162 | | 1606 | |
| Perquimans River, N. C., improvement of | 87 | 626 | | |
| Petaluma Creek, Cal., examination and survey of | 179 | | | |
| Plattsburgh Harbor, N. Y., improvement of | 65 | 395 | | |
| Pier and bulkhead lines of Baltimore Harbor, report on | 76 | 497 | | |
| Plymouth Harbor, Mass., improvement of | 50 | 271 | | |
| Pocomoke River, Md., improvement of | 77 | 505 | | |
| Port Chester Harbor, N. Y., improvement of | 63 | 390 | | |
| Port Clinton Harbor, Ohio, improvement of | 171 | | 1671, 1681 | |
| Port Jefferson Harbor, L. I., N. Y., improvement of | 59 | 358 | | |
| Portland Harbor, Me., improvement of | 46 | 255 | | |
| Port Orford, Oreg., examination of, for harbor of refuge | 183 | | 1802 | |
| Portsmouth Harbor, N. H., survey of | 52 | 282 | | |
| Portsmouth Harbor, N. H., improvement of | 48 | 262 | | |
| Port Royal River, S. C., examination and survey of | 100 | | | |
| Port-warden's line at Philadelphia | 74 | 462 | | |
| Port Washington Harbor, Wis., improvement of | 154 | | 1519 | |
| Providence River, R. I., improvement of | 54 | 306 | | |
| Provincetown Harbor, Mass., improvement of | 51 | 273 | | |
| Public Buildings and Grounds, District of Columbia | 183 | | 1877 | |
| Pultneyville Harbor, N. Y., improvement of | 176 | | 1728 | |
| **Q.** | | | | |
| Quincy, Ills., examination of Mississippi River at | 133 | | 1130 | |
| Quincy, Ills, improvement of Mississippi River at | 130 | | 1130 | |
| Queenstown, Md., improvement of harbor at | 75 | 487 | | |
| **R.** | | | | |
| Racine Harbor, Wis., improvement of | 155 | | 1526 | |
| Rahway River, N. J., improvement of | 67 | | | |
| Rahway River, N. J., examination of | 75 | 483 | | |
| Rappahannock River, Va., improvement of | 85 | 607 | | |
| Raritan River, N. J., improvement of | 64 | 392 | | |
| Reconnaissances and explorations | 188 | | | |
| Red River, La.: | | | | |
| examination for improvement of falls of | 118 | | | |
| improvement of upper | 114 | | 964 | |
| examination of upper | 118 | | 986 | |
| improvement of mouth of | 113 | | 959 | |
| removing snags from | 114 | | 961 | |
| Red River Raft, La., removal of | 112 | | 951 | |
| Red River of the North, improvement of | 135 | | 1189 | |
| Reedy Island, Delaware River, ice harbor at | 73 | 444 | | |
| Reservoirs at sources of Mississippi River, survey for | 136 | | 1193 | |
| Richmond's Island, Me., harbor of refuge at | 46 | 257 | | |
| River and harbor improvements | 42 | | | |
| Roanoke River, N. C., improvement of | 87 | 624 | | |
| Rock Island Bridge, sheer-booms at | 132 | | 1144 | |
| Rock Island Rapids, Mississippi River, improvement of | 131 | | 1132 | |
| Rogue River, Oreg., examination of | 183 | | 1823, 1856 | |
| Rondout Harbor, N. Y., improvement of | 60 | 374 | | |
| **S.** | | | | |
| Sabine Pass, Tex., improvement of | 108 | 902 | | |
| Sabine River, Tex., improvement of | 108 | 904 | | |

# INDEX.

| Subject. | Page. | | | |
|---|---|---|---|---|
| | Part I. | | Part II. | Part III. |
| Sabine River, Tex., examination and resurvey of | 112 | | | |
| Sacramento and Feather rivers, Cal., improvement of | 178 | | 1749 | |
| Sacramento River, Cal., examination and survey of | 179 | | | |
| Saginaw River, Mich., improvement of | 169 | | 1659 | |
| Saint Anthony, preservation of Falls of | 134 | | 1159 | |
| Saint Augustine Creek, Ga., improvement of | 97 | 763 | | |
| Saint Charles, Mo., examination of Missouri River at | 127 | | 1083 | |
| Saint Clair Flats ship-canal, Mich | 168 | | 1651 | |
| Saint Clair River at the mouth of Black River, Mich., improvement of | 169 | | 1656 | |
| Saint Croix River, Me., improvement of | 43 | 245 | | |
| Saint Croix River, Wis., improvement of | 135 | | 1179 | |
| Saint John's River and Fernandina, Fla., deepening inside passage between | 98 | 765 | | |
| Saint John's River, Fla., examination of upper | 99 | 795 | | |
| Saint John's River, Fla., survey and improvement of bar at mouth of | 98 | 766 | | |
| Saint Joseph, Mo., improvement of Missouri River at | 123 | | 1065 | |
| Saint Joseph's Harbor, Mich., improvement of | 166 | | 1631 | |
| Saint Joseph River, Mich., from mouth to Elkhart, Ind., examination and survey of | 167 | | | |
| Saint Louis Harbor, Mo., improvement of | 118 | | 1024 | |
| Saint Mary's Falls Canal, Mich., construction of | 167 | | 1641 | |
| Saint Mary's Falls Canal, approaches to, survey of | 168 | | | |
| Salem River, N. J., improvement of | 68 | 412 | | |
| Salem River, N. J., survey and examination of | 75 | 474 | | |
| Saline River, Ark., examination of | 118 | | 1003 | |
| San Buenaventura Harbor, Cal., examination of | 180 | | 1770 | |
| San Diego Harbor, Cal., improvement of | 179 | | 1763 | |
| Sandusky City Harbor, Ohio, improvement of | 171 | | 1672, 1682 | |
| San Joaquin River, Cal., improvement of | 179 | | 1764 | |
| San Luis Obispo, Cal., examination of harbor at | 180 | | 1765 | |
| Santa Barbara Harbor, Cal., examination of | 180 | | 1769 | |
| Santee River, S. C., examination and survey of | 95 | | | |
| Saugatuck Harbor, Mich., improvement of | 165 | | 1625 | |
| Savannah Harbor and River, Ga., improvement of | 96 | 740 | | |
| Savannah River, Ga., survey of, above Augusta | 99 | 747 | | |
| Saybrook Bar, mouth of Connecticut River, jetty at | 56 | 317 | | |
| Schuylkill River, Pa., improvement of | 69 | 416 | | |
| Scituate Harbor, Mass., survey of | 52 | 284 | | |
| Scuppernong River, N. C., improvement of | 92 | 698 | | |
| Sea-coast and lake-frontier defenses | 4 | | | |
| Sebewaing Harbor, Mich., resurvey of | 170 | | | |
| Secretary Creek, Md., examination and survey of | 81 | | | |
| Seekonk River, R. I., improvement of | 54 | 305 | | |
| Sheboygan Harbor, Wis., improvement of | 154 | | 1518 | |
| Sheepshead Bay, N. Y., examination of | 66 | 400 | | |
| Sheer-booms at Rock Island Bridge, construction of | 132 | | 1144 | |
| Shenandoah River, Va. and W. Va., examination and survey of | 81 | | | |
| Ship Canal between Delaware and Chesapeake Bays, survey for | 81 | 587 | | |
| Ship Canal across Bergen Neck, N. J., examination and survey for | 66 | | | |
| Ship Canal from Saint Mary's River, Fla., to the Gulf of Mexico, survey for | 99 | | | |
| Shrewsbury River, N. J., improvement of | 66 | 403 | | |
| Sioux City, Iowa, improvement of Missouri River at | 124 | | 1078 | |
| Sipsey River, Ala., examination and survey of | 106 | | | |
| Slaughter Creek, Md., examination and survey of | 81 | | | |
| Snagboats on the Mississippi, Missouri, and Arkansas Rivers | 120 | | 1049 | |
| Snake River, Wash., improvement of | 181 | | 1789, 1839 | |
| Sodus Harbor, N. Y., Great, improvement of | 176 | | 1729 | |
| Sodus Harbor, N. Y., Little, improvement of | 176 | | 1731 | |

| Subject. | Page. Part I. | | Page. Part II. | Page. Part III. |
|---|---|---|---|---|
| South Haven Harbor, Mich., improvement of | 165 | | 1627 | |
| South River, N. J., examination and survey of | 66 | | | |
| Southport Harbor, Conn., improvement of | 59 | 354 | | |
| Staten Island, N. Y., improvement of New Jersey Channel | 64 | 392 | | |
| Staunton River, Va., improvement of | 86 | 621 | | |
| Staunton River, Va., examination of | 88 | 622 | | |
| Stonington Harbor, Conn., improvement of | 56 | 326 | | |
| Sturgeon Bay Canal, Wis., harbor of refuge at | 152 | | 1488 | |
| Superior Bay and entrance, Wis., improvement of | 150 | | 1468 | |
| Superior Bay for harbor improvement, examination and survey of | 136 | | | |
| Survey of northern and northwestern lakes and of the Mississippi River | 184 | | | 1891 |
| Surveys and examinations for improvement of rivers and harbors, estimates for | 184 | | | |
| Surveys and explorations 40th parallel, completion of | 186 | | | |
| Surveys and explorations west of the 100th meridian | 186 | | | 1977 |
| Susquehanna River, Pa., examination and survey of | 75 | | | |
| Suwannee River, Fla., examination of | 106 | 857 | | |
| Susquehanna River, near Havre de Grace, Md., improvement of | 75 | 487 | | |
| Swanton Harbor, Vt., improvement of | 65 | 396 | | |
| **T.** | | | | |
| Tallahatchie River, Miss., examination of | 118 | | 985 | |
| Tallahatchie River, Miss., improvement of | 116 | | 971 | |
| Tampa Bay, Fla., examination of | 106 | 870 | | |
| Tangipahoa River, examination of | 111 | 946 | | |
| Tar River, N. C., improvement of | 92 | 700 | | |
| Tar River, N. C., examination of | 95 | 700 | | |
| Taunton River, Mass., improvement of | 54 | 303 | | |
| Tchefuncta River, La., examination and survey of | 112 | | | |
| Tchula Lake, Miss., examination and survey of | 118 | | 1247 | |
| Teche Bayou, La., examination and survey of | 112 | | | |
| Tennessee River above Chattanooga, improvement of | 137 | | 1247 | |
| Tennessee River below Chattanooga, improvement of | 137 | | 1248 | |
| Tickfaw River, La., examination and survey of | 112 | | | |
| Thames River, Conn., improvement of | 57 | 331 | | |
| Thunderbolt River, Ga., improvement of | 97 | 763 | | |
| Toledo Harbor, Ohio, improvement of | 170 | | 1670, 1678 | |
| Tombigbee River, Ala., improvement of | 104 | 830 | | |
| Tombigbee River, above Columbus, Miss., improvement of | 105 | 833 | | |
| Tone's Bayou, La., closing of | 112 | | 951 | |
| Tone's Bayou, La., examination of | 118 | | 991 | |
| Torpedo defense | 35 | | | |
| Tread Haven Creek, Md., examination and survey of | 81 | | | |
| Trent River, N. C., improvement of | 94 | 711 | | |
| Trent River, N. C., examination of | 95 | 711 | | |
| Trinidad Harbor, Cal., examination and survey of | 180 | | | |
| Trinity River, Tex., examination and resurvey of | 112 | | | |
| Trinity River, Tex., improvement of | 110 | 918 | | |
| Tuckahoe Creek, Md., examination and survey of | 81 | | | |
| Two Rivers Harbor, Wis., improvement of | 153 | | 1512 | |
| **U.** | | | | |
| Umpqua River, Oreg., &c., examination and survey of | 183 | | | |
| Upper Columbia and Snake Rivers, Oreg., and Wash., improvement of | 181 | | 1789, 1839 | |
| Upper Mississippi River, improvement of | 134 | | 1165 | |
| Upper Willamette River, Oreg., improvement of | 181 | | 1788, 1831 | |
| Urbana Creek, Va., improvement of | 85 | 616 | | |

| Subject. | Page. | | | |
|---|---|---|---|---|
| | Part I. | | Part II. | Part III. |
| **V.** | | | | |
| Venice, Ill., examination of Mississippi River at | 120 | | | |
| Vermillion Harbor, Ohio, improvement of | 172 | | 1673, 1687 | |
| Vicksburg, Miss., improvement of harbor at | 116 | | 974 | |
| Vermillion, Dak., improvement of Missouri River at | 125 | | 1079 | |
| **W.** | | | | |
| Wabash River, Ind., improvement of | 147 | | 1439 | |
| Waccamaw River, N. C., survey of | 95 | | | |
| Wachita River, Ark. and La., improvement of | 114 | | 965 | |
| Waddington Harbor, N. Y., improvement of | 177 | | 1738 | |
| Wareham Harbor, Mass., improvement of | 53 | 300 | | |
| Warrior River, Ala., examination and survey of | 106 | | | |
| Washington and Georgetown Harbors, D. C., improvement of | 82 | 591 | | |
| Washington Aqueduct, D. C. | 184 | | 1885 | |
| Wateree River, S. C., examination and survey of | 95 | | | |
| Water communication between Gulf of Mexico and Atlantic Ocean, survey for | 99 | | | |
| Water communication between Norfolk, Va., and the Atlantic Ocean south of Hatteras, survey for | 94 | 714 | | |
| Water communication between Delaware and Chesapeake bays, surveys for | 81 | 587 | | |
| Water-gauges on Mississippi River and tributaries | 117 | | 982 | |
| Waukegan Harbor, Ill., examination and survey of | 157 | | | |
| Westport Harbor, Mass., survey of | 56 | 320 | | |
| White River at Buffalo Shoal, Ark., improvement of | 115 | 126 | 969 | |
| White and Saint Francis rivers, Ark., improvement of | 115 | | 968 | |
| White River Harbor, Mich., improvement of | 163 | | 1613 | |
| White River, Ind., examination of | 149 | | | |
| White River, Ind., improvement of | 148 | | 1454 | |
| Wicomico River, Md., improvement of | 77 | 502 | | |
| Willamette River, Lower, Oreg., improvement of | 180 | | 1787, 1825 | |
| Willamette River, Upper, Oreg., improvement of | 181 | | 1788, 1831 | |
| Wilmington, Cal., construction of breakwater at | 178 | | 1746 | |
| Wilmington Harbor, Del., improvement of | 72 | 441 | | |
| Wilson Harbor, N. Y., improvement of | 175 | | 1725 | |
| Winnepesaukee Lake, N. H., outlet of, examination and survey of | 52 | | | |
| Wisconsin and Fox rivers, improvement of | 156 | | 1531 | |
| Withlacoochee River, Fla., examination and survey of. | 106 | | | |
| Wolf Lake Outlet, Ind., examination and resurvey of | 160 | | | |
| Wolf River, Wis., examination of | 156 | | | |
| Woodbridge Creek, N. J., examination of | 75 | 478 | | |
| Woodbridge Creek, N. J., improvement of | 67 | | | |
| Wood's Holl, survey of | 56 | | | |
| Wood's Holl Harbor, Mass., improvement of | 53 | 297 | | |
| **Y.** | | | | |
| Yadkin River, N. C., improvement of | 87 | 626 | | |
| Yadkin River, N. C., examination of | 88 | 627 | | |
| Yallabusha River, Miss., examination and survey of | 118 | | | |
| Yazoo River, Miss., improvement of | 115 | | 967 | |
| Yellowstone River, improvement of | 128 | | 1095 | |
| Yellowstone River, survey of | 128 | | 1097 | |
| Yellowstone River, examination and continuing survey of | 128 | | | |
| York River, Va., survey of | 95 | | | |

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